

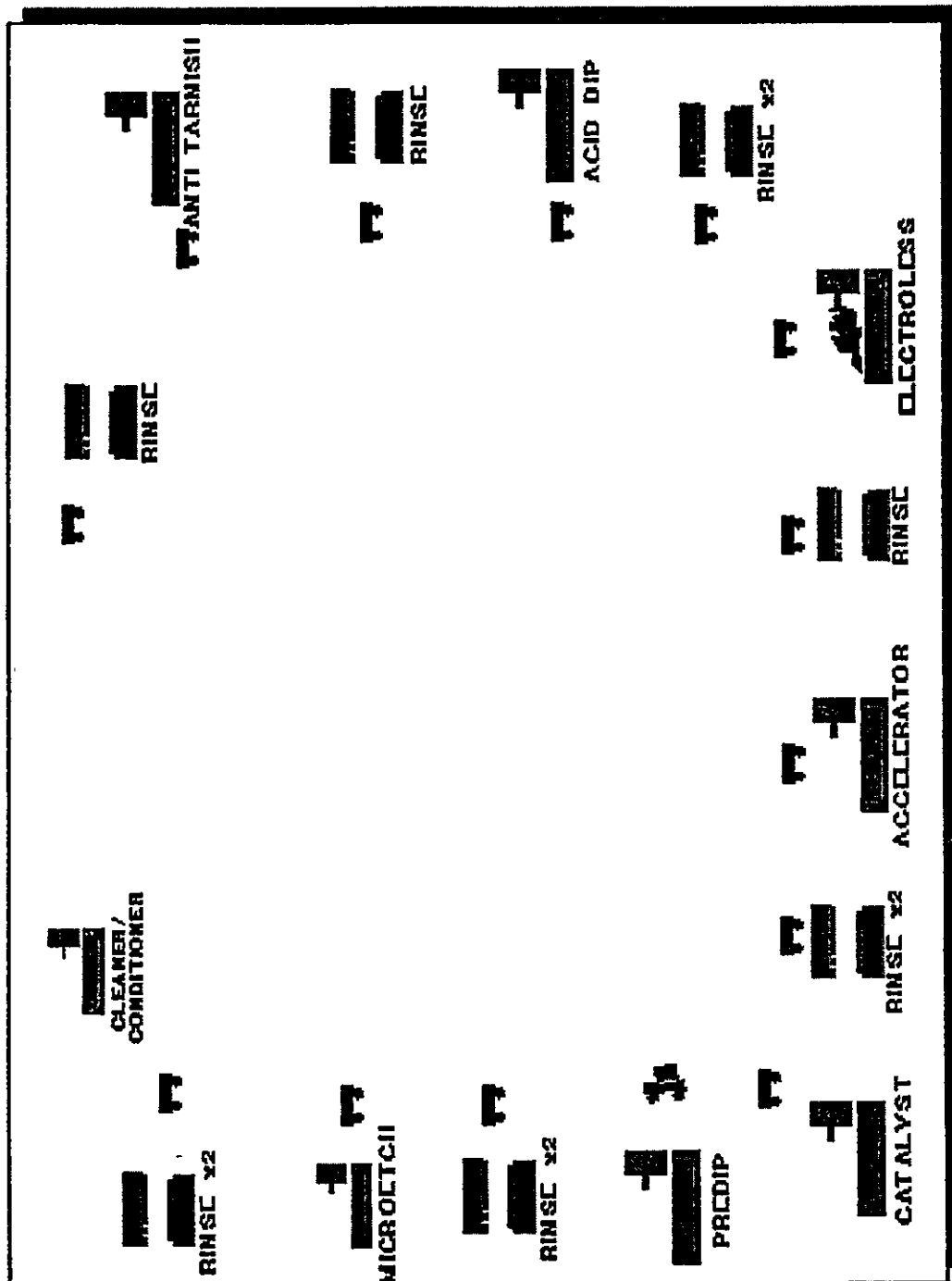
Appendix G

Supplemental Cost Analysis Information

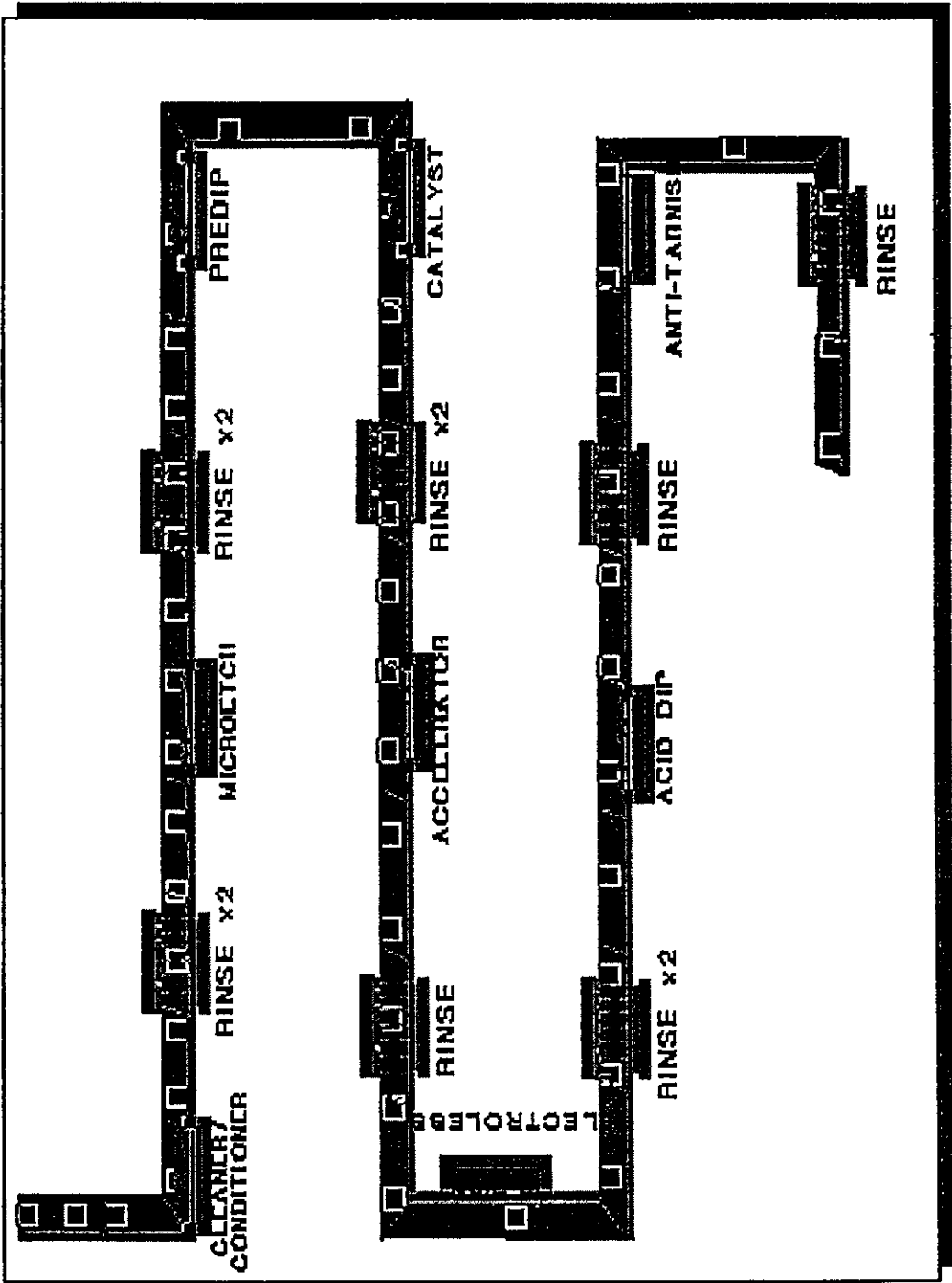
- G.1 Graphic Representations of Cost Simulation Models for MHC Alternatives
- G.2 Bath Replacement Criteria for MHC Alternatives
- G.3 Bills of Activities for the MHC Process
- G.4 Simulation Model Outputs for MHC Alternatives
- G.5 Chemical Costs by Bath for Individual MHC Processes
Total Materials Cost by MHC Alternative
- G.6 Sensitivity Analyses

G.1 Graphic Representations of Cost Simulation Models for MHC Alternatives

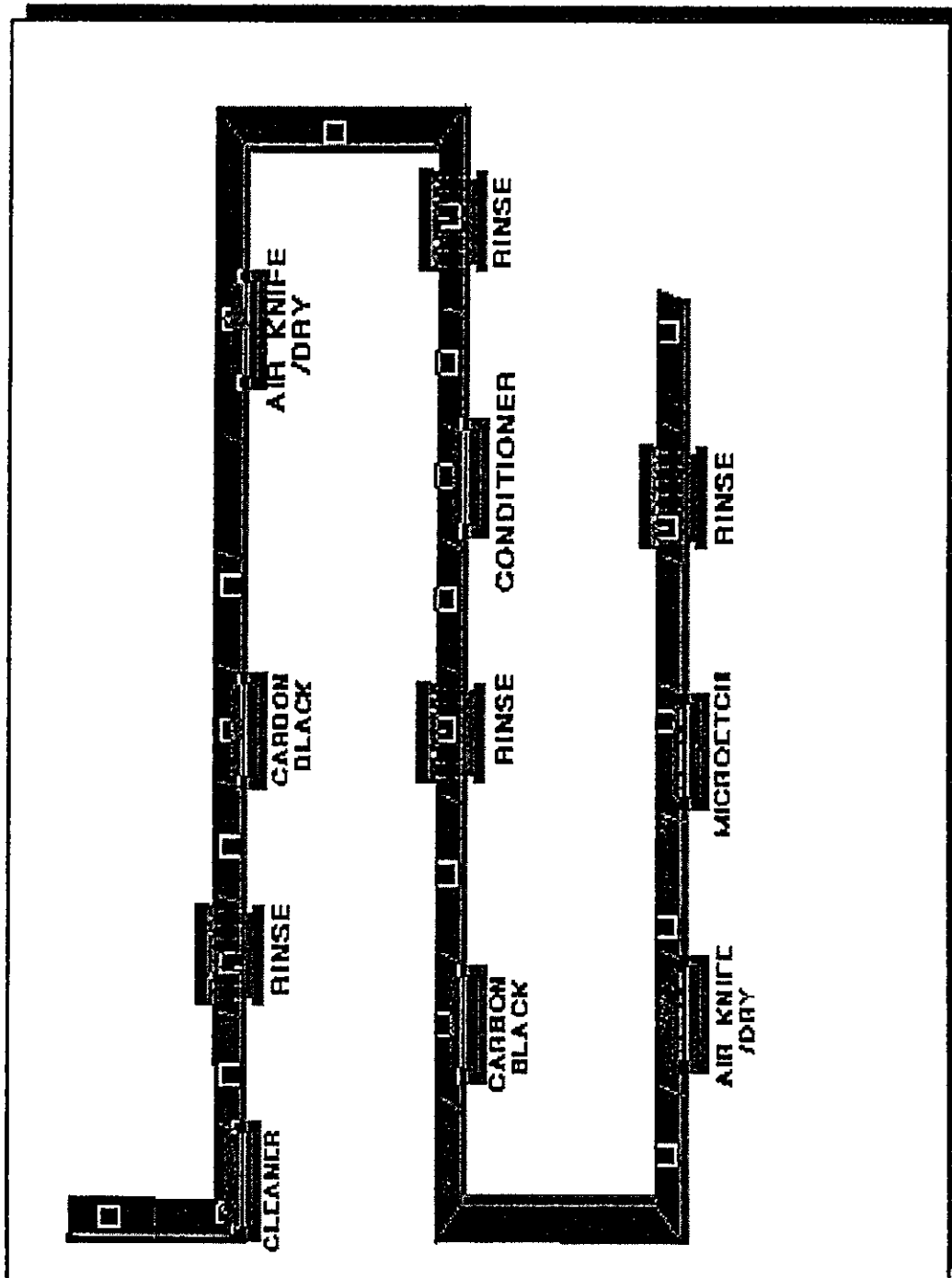
Electroless Copper Process, Non-ConveyORIZED



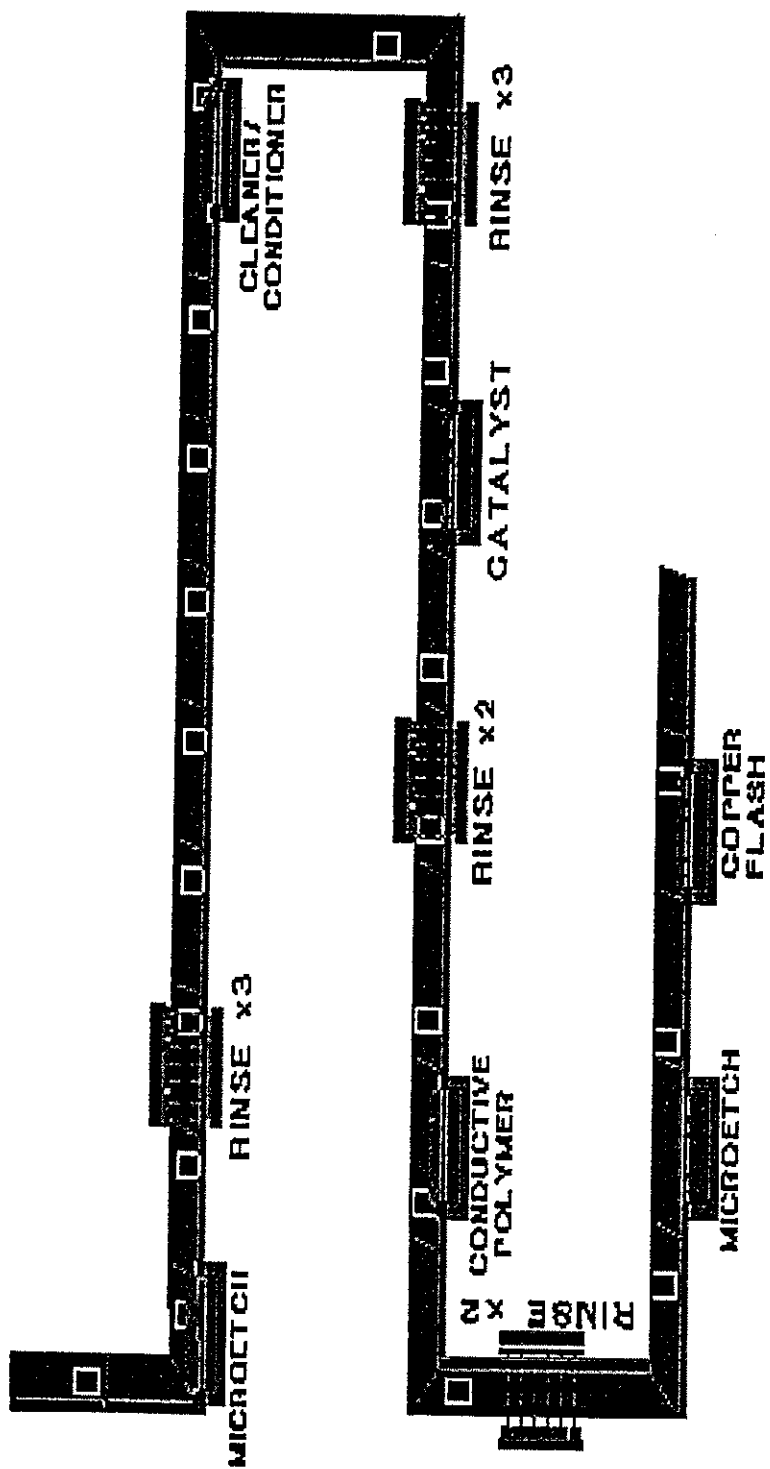
Electroless Copper Process, ConveyORIZED



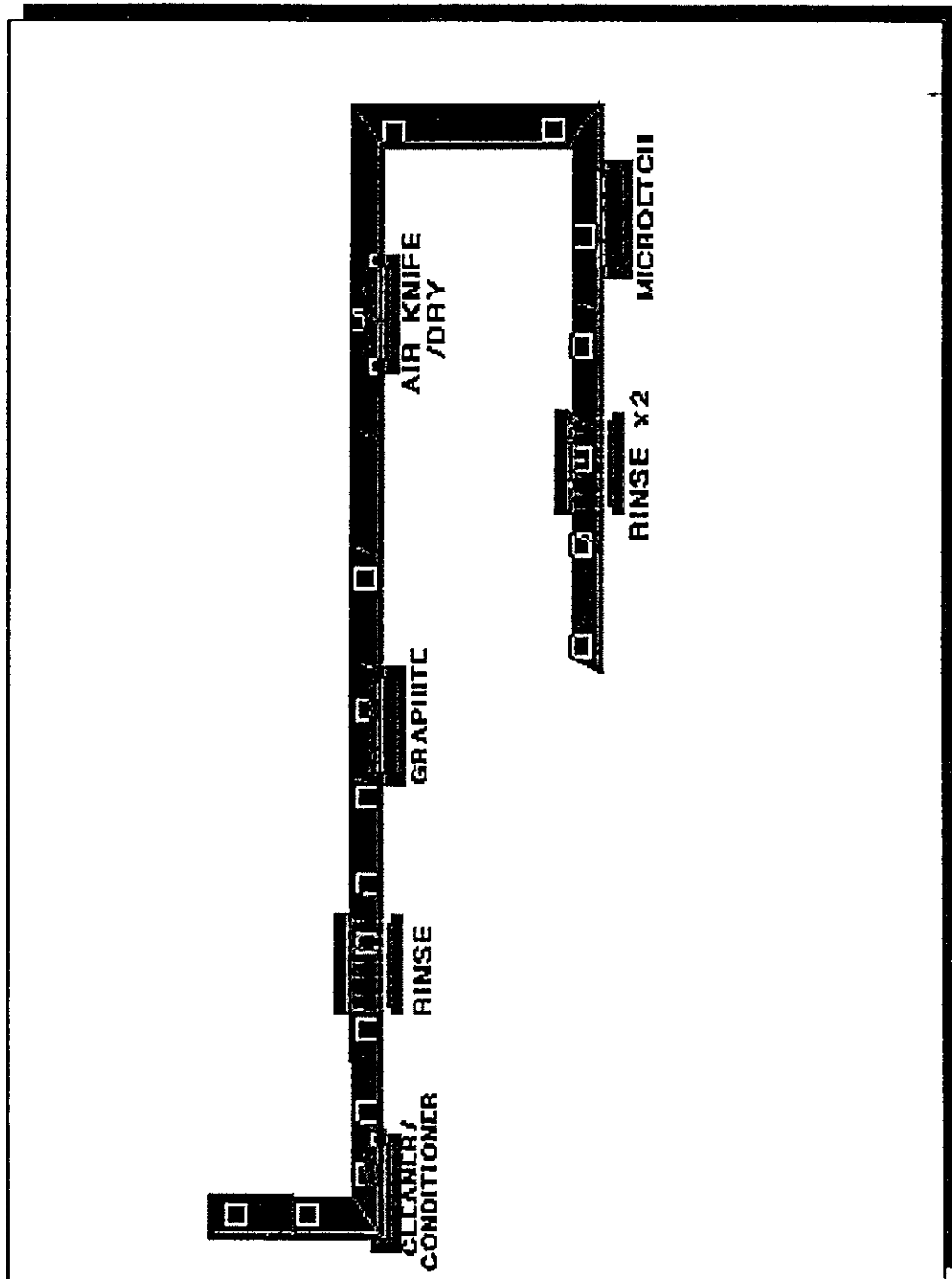
Carbon Process, Conveyorized



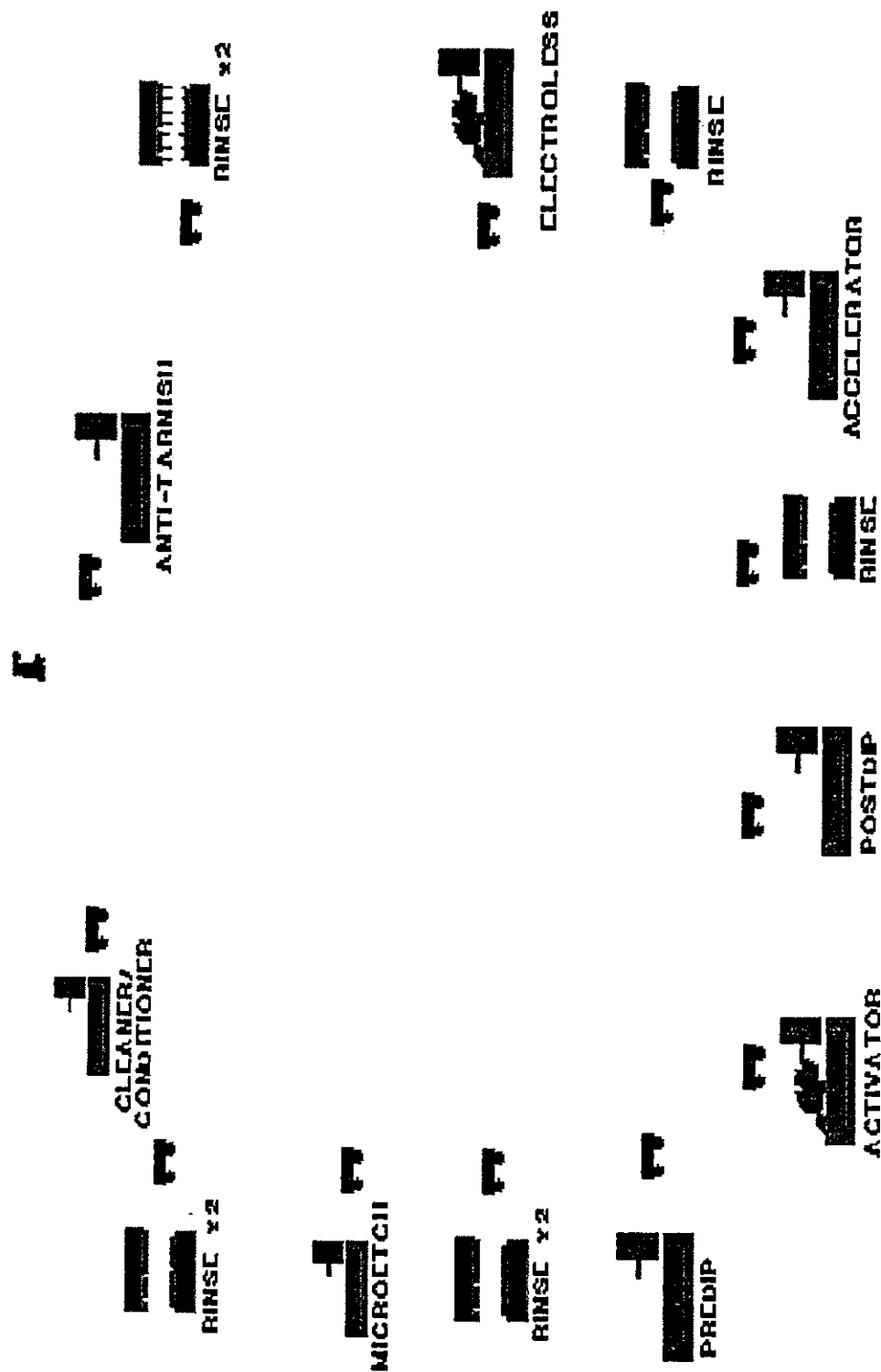
Conductive Polymer Process, Conveyorized



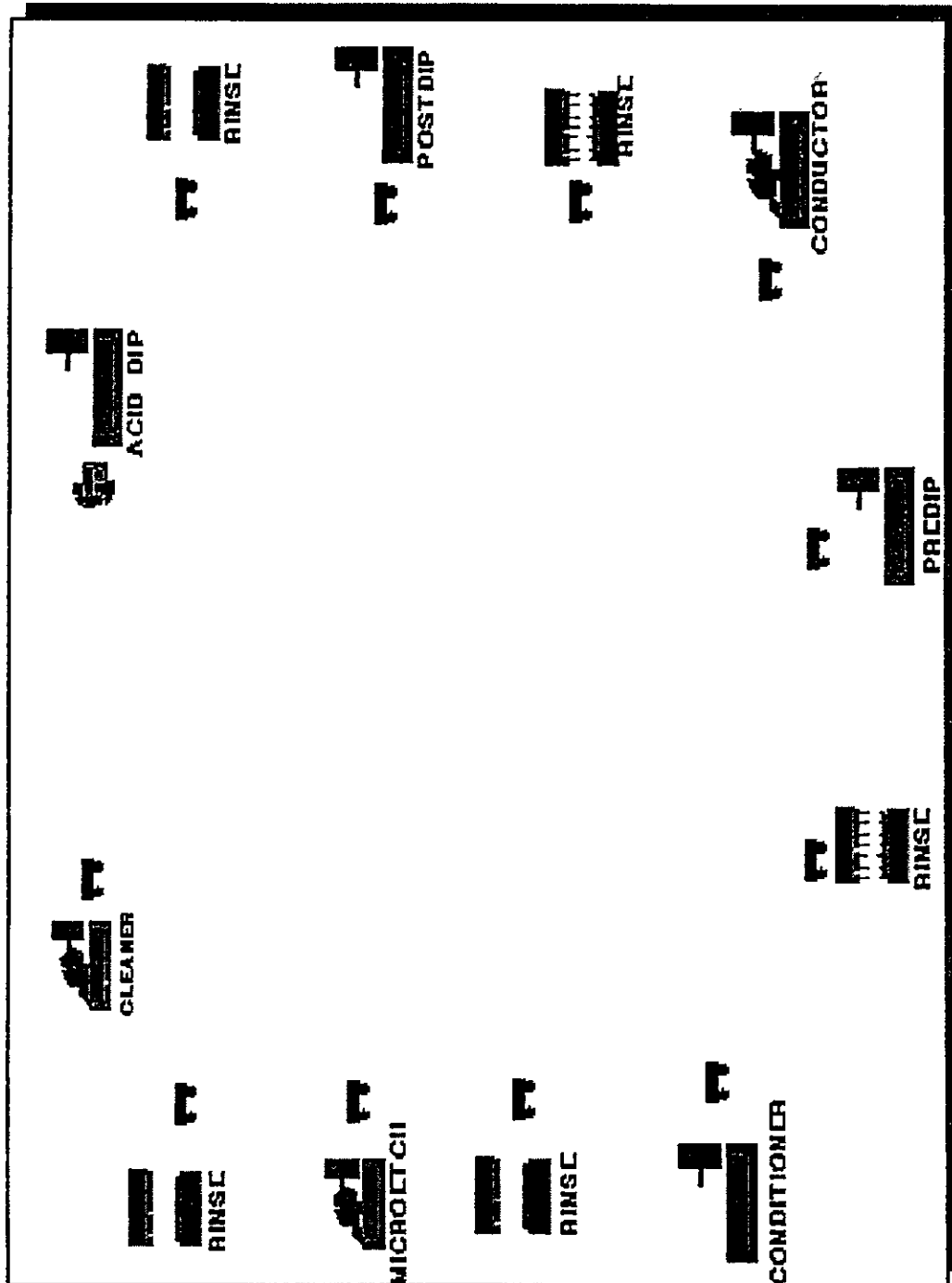
Graphite Process, ConveyORIZED



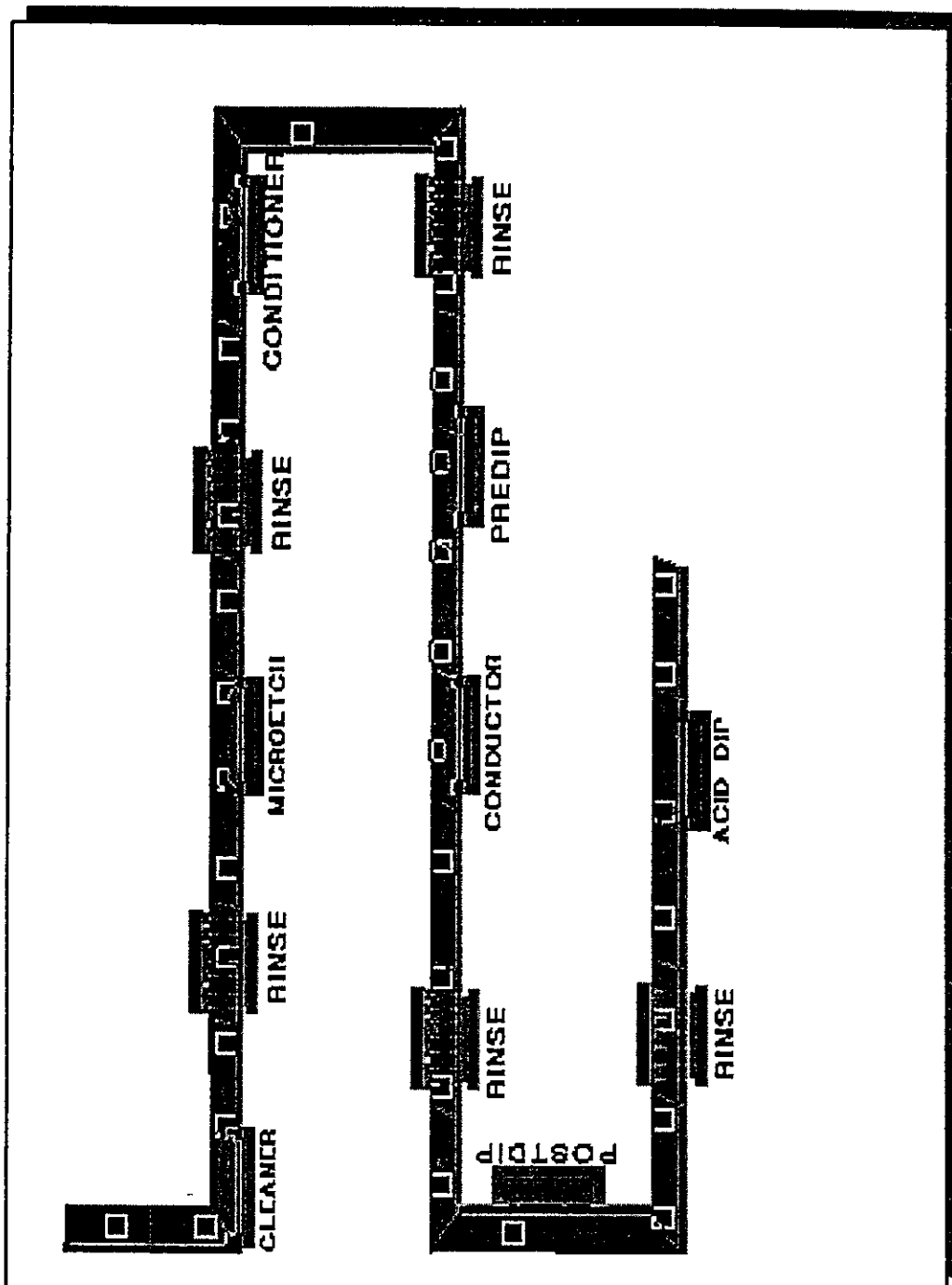
Non-Formaldehyde Electroless Copper Process, Non-ConveyORIZED



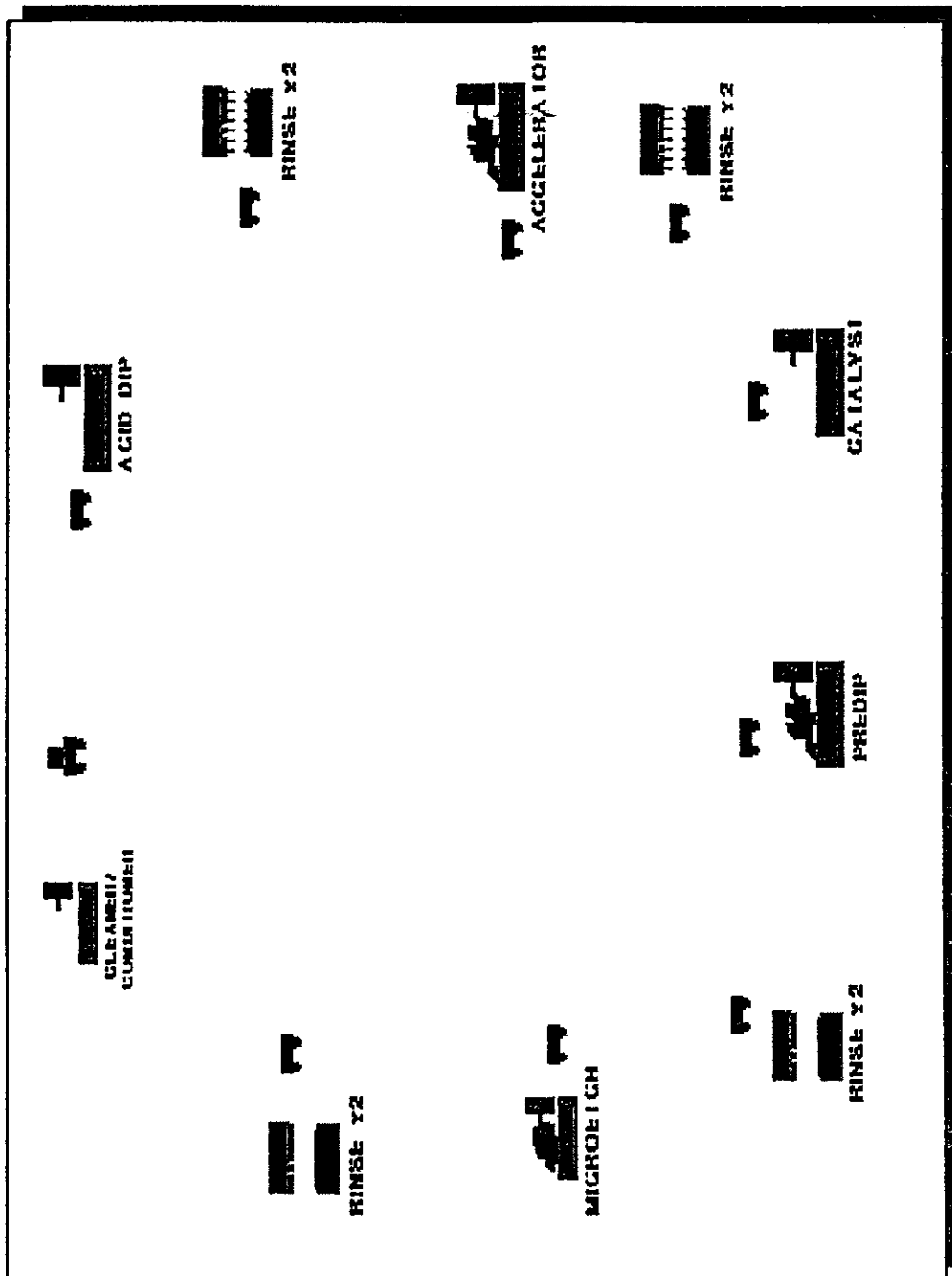
Organic-Palladium Process, Non-ConveyORIZED



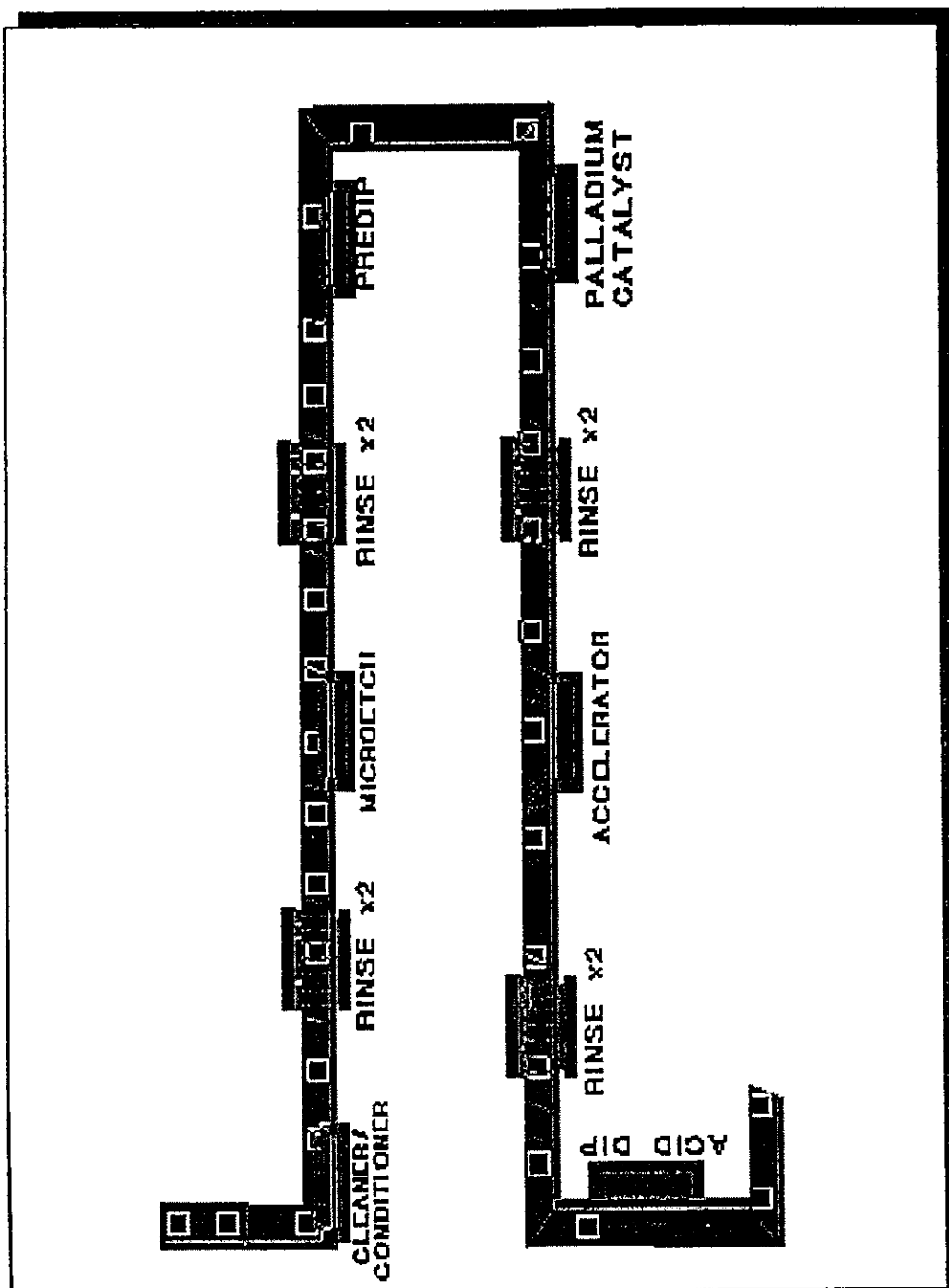
Organic-Palladium Process, ConveyORIZED



Tin-Palladium Process, Non-Conveyorized



Tin-Palladium Process, ConveyORIZED



G.2 Bath Replacement Criteria for MHC Alternatives

Electroless Copper - Non-Conveyorized (Baseline)

Electroless Copper - Conveyorized

Non-Formaldehyde Electroless Copper - Non-Conveyorized^A

Process Step	Bath Replacement Frequencies (ssf/gal) ¹						Frequency of Replacement Cost Simulation Inputs ³	
	Process # 1	Process # 2	Process # 3	Process # 4	Process # 5	Average Frequency of Replacement ²	Conveyorized (Panels)	Non-Conveyorized (Racks)
Cleaner/Conditioner	Conc.	228	500	300	1,000	510	5,920	396
Micro-Etch	Conc.	ND	250	ND	Conc.	250	2,858	194
Predip	Conc.	228	Conc.	400	1,000	540	4,822	418
Catalyst	300	Conc.	500	6 mos	Conc.	1/year	1/year	1/year
Post Dip/Acid Dip	ND	ND	1,000	ND	350	675	9,523	523
Accelerator	360	160	2,500 *	250	350	280	4,000	217
Electroless Copper	360	Conc.	500	ND	Conc.	430	14,206	334
Anti-Tarnish	200	ND	250	ND	500	325	2,264	252

ND = No Data

NA = Not Applicable

Conc. = Replacement data given in concentration (e.g, g/L Cu) so not usable in this analysis.

* - data point considered outlier and thus not included in calculation of average.

^A Incomplete bath replacement data submitted for non-formaldehyde copper process. Therefore, the process was assumed to be similar to electroless copper for the purposes of bath replacement.

¹ Bath replacement frequency data for MHC product lines reported on product data sheets provided by chemical supplier of each individual process.

² Reported value was calculated by excluding any outlying values and then averaging remaining bath replacement data for each bath.

³ To calculate panels per bath replacement, multiply average frequency of replacement by bath size in gallons and divide by 5.6 ssf/panel.

To calculate racks per bath replacement, multiply average frequency of replacement by 75 gallons (average bath size) and divide by 96.8 ssf/rack.

Carbon - Conveyorized

Process Step	Bath Replacement Frequencies (ssf/gal) ¹						Frequency of Replacement Cost Simulation Inputs ³	
	Process # 1	Process # 2	Process # 3	Process # 4	Process # 5	Average Frequency of Replacement ²	Conveyorized (Panels)	Non-Conveyorized (Racks)
Cleaner	300	NA	NA	NA	NA	300	2,340	NA
Carbon Black	1/year	NA	NA	NA	NA	1/year	1/year	NA
Conditioner	300	NA	NA	NA	NA	300	2,961	NA
Carbon Black	1/year	NA	NA	NA	NA	1/year	1/year	NA
Micro-Etch	ND	NA	NA	NA	NA	250**	2,855	NA

NA = No Data

NA = Not Applicable

Conc. = Replacement data given in concentration (e.g., g/L Cu) so not usable in this analysis.

** - Due to lack of replacement data, the frequency of replacement of the micro-etch bath was assumed to be the same as for electroless copper.

¹ Bath replacement frequency data for MHC product lines reported on product data sheets provided by chemical supplier of each individual process.

² Reported value was calculated by excluding any outlying values and then averaging remaining bath replacement data for each bath.

³ To calculate panels per bath replacement, multiply average frequency of replacement by bath size in gallons and divide by 5.6 ssf/panel.

Conductive Polymer - Conveyorized

Process Step	Bath Replacement Frequencies (ssf/gal) ¹						Frequency of Replacement Cost Simulation Inputs ³	
	Process # 1	Process # 2	Process # 3	Process # 4	Process # 5	Average Frequency of Replacement ²	Conveyorized (Panels)	Non-Conveyorized (Racks)
Micro-Etch	ND	NA	NA	NA	NA	250**	2,855	NA
Cleaner/Conditioner	408	NA	NA	NA	NA	410	4,681	NA
Cleaner/Conditioner	408	NA	NA	NA	NA	410	4,681	NA
Catalyst	4,880	NA	NA	NA	NA	4,880	11,985	NA
Conductive Polymer	1,935	NA	NA	NA	NA	1,940	8,918	NA
Micro-Etch	ND	NA	NA	NA	NA	250**	2,855	NA

NA = No Data

NA = Not Applicable

Conc. = Replacement data given in concentration (e.g., g/L Cu) so not usable in this analysis.

** - Due to lack of replacement data, the frequency of replacement of the micro-etch bath was assumed to be the same as for electroless copper.

¹ Bath replacement frequency data for MHC product lines reported on product data sheets provided by chemical supplier of each individual process.

² Reported value was calculated by excluding any outlying values and then averaging remaining bath replacement data for each bath.

³ To calculate panels per bath replacement, multiply average frequency of replacement by bath size in gallons and divide by 5.6 ssf/panel.

Organic Palladium - Conveyorized
Organic Palladium - Non-Conveyorized

Process Step	Bath Replacement Frequencies (ssf/gal) ¹						Frequency of Replacement Cost Simulation Inputs ³	
	Process # 1	Process # 2	Process # 3	Process # 4	Process # 5	Average Frequency of Replacement ²	Conveyorized (Panels)	Non-Conveyorized (Racks)
Cleaner	200	NA	NA	NA	NA	200	1,560	155
Micro-Etch	ND	NA	NA	NA	NA	250**	2,855	194
Conditioner	244	NA	NA	NA	NA	240	2,411	189
Predip	1/week	NA	NA	NA	NA	1/week	1/week	NA
Conductor	2,038	NA	NA	NA	NA	2,040	39,007	1,580
Post Dip	244	NA	NA	NA	NA	240	1,950	189
Acid Dip	200	NA	NA	NA	NA	200	2,801	155

ND = No Data

NA = Not Applicable

Conc. = Replacement data given in concentration (e.g, g/L Cu) so not usable in this analysis.

** - Due to lack of replacement data, the frequency of replacement of the micro-etch bath was assumed to be the same as for electroless copper.

¹ Bath replacement frequency data for MHC product lines reported on product data sheets provided by chemical supplier of each individual process.

² Reported value was calculated by excluding any outlying values and then averaging remaining bath replacement data for each bath.

³ To calculate panels per bath replacement, multiply average frequency of replacement by bath size in gallons and divide by 5.6 ssf/panel.

To calculate racks per bath replacement, multiply average frequency of replacement by 75 gallons (average bath size) and divide by 96.8 ssf/rack.

Graphite - Conveyorized

Process Step	Bath Replacement Frequencies (ssf/gal) ¹						Frequency of Replacement Cost Simulation Inputs ³	
	Process # 1	Process # 2	Process # 3	Process # 4	Process # 5	Average Frequency of Replacement ²	Conveyorized (Panels)	Non-Conveyorized (Racks)
Cleaner/Conditioner	200	750	NA	NA	NA	475	5,443	NA
Graphite	Conc.	3,000	NA	NA	NA	3,000	19,415	NA
Micro-Etch	Conc.	ND	NA	NA	NA	250**	2,855	NA

ND = No Data

NA = Not Applicable

Conc. = Replacement data given in concentration (e.g, g/L Cu) so not usable in this analysis.

** - Due to lack of replacement data, the frequency of replacement of the micro-etch bath was assumed to be the same as for electroless copper.

¹ Bath replacement frequency data for MHC product lines reported on product data sheets provided by chemical supplier of each individual process.

² Reported value was calculated by excluding any outlying values and then averaging remaining bath replacement data for each bath.

³ To calculate panels per bath replacement, multiply average frequency of replacement by bath size in gallons and divide by 5.6 ssf/panel.

Tin-Palladium - Conveyorized
Tin-Palladium - Non-Conveyorized

Process Step	Bath Replacement Frequencies (ssf/gal) ¹						Frequency of Replacement Cost Simulation Inputs ³	
	Process # 1	Process # 2	Process # 3	Process # 4	Process # 5	Average Frequency of Replacement 2	Conveyorized (Panels)	Non-Conveyorized (Racks)
Cleaner/Conditioner	350	1,000	500	2 weeks	NA	610	6,879	465
Micro-Etch	Conc.	Conc.	250	Conc.	NA	250**	2,855	194
Predip	400	4,000*	500	Conc.	NA	450	3,972	349
Catalyst	3,000	Conc.	2,500	1,000	NA	1/year	1/year	1/year
Accelerator	500	1,000	500	400	NA	600	8,457	465
Acid Dip	500	ND	1,000	210	NA	570	7,961	442

ND = No Data

NA = Not Applicable

Conc. = Replacement data given in concentration (e.g, g/L Cu) so not usable in this analysis.

** - Due to lack of replacement data, the frequency of replacement of the micro-etch bath was assumed to be the same as for electroless copper.

¹ Bath replacement frequency data for MHC product lines reported on product data sheets provided by chemical supplier of each individual process.

² Reported value was calculated by excluding any outlying values and then averaging remaining bath replacement data for each bath.

³ To calculate panels per bath replacement, multiply average frequency of replacement by bath size in gallons and divide by 5.6 ssf/panel.

To calculate racks per bath replacement, multiply average frequency of replacement by 75 gallons (average bath size) and divide by 96.8 ssf/rack.

G.3 Bills of Activities for the MHC Process

Activities Associated with the Bath Setup

Activity Description	Cost Driver	Cost/Activity
Wear masks, goggles, rubber gloves, and suitable clothing	\$/bath setup	\$2.50
Go to storage area	labor	
Locate protective equipment	labor	
Put on protective equipment	labor	
	protective equipment	
Return to tank	labor	
Put in base liquid (usually water)	\$/bath setup	\$2.60
Open water valve	labor	
Wait for measured amount	labor	
Close water valve	labor	
Document water amount/level	labor	
Mix the bath solution	\$/bath setup	\$5.00
Open the chemical containers	labor	
Add the chemicals to the bath	labor	
Turn on the agitator	labor	
Wait for mixing	labor	
Turn off the agitator	labor	
Titrate sample	labor	
Document	labor	
Repeat as necessary	labor	
Flush containers	\$/bath setup	\$3.00
Turn on water valve	labor	
Spray containers	labor	
Turn off water valve	labor	
Place empty container in storage area	\$/bath setup	\$2.00
Take container to storage	labor	
Documentation	labor	
Return to tank	labor	
Total =	\$per testing	\$15.10

Activities Associated with the Tank Cleanup

Activity Description	Cost Driver	Cost/Activity
Rinse with water	\$/cleanup	\$25.00
Obtain spray/rinse equipment	labor	
Turn water on	labor	
Spray equipment	labor	
Turn water off	labor	
Obtain scrubbing and cleaning tools	\$/cleanup	\$1.00
Go to storage area	labor	
Find necessary tools	labor	
Return to tank	labor	
Hand scrub tank	\$/cleanup	\$30.00
Put on gloves, choose tool	labor	
Scrub tank	labor	
	cleaning supplies	
Return cleaning tools	\$/cleanup	\$1.25
Go to the storage area	labor	
Place tools in correct place	labor	
Return to tank	labor	
Spray according to schedule	\$/cleanup	\$5.00
Wait for time to elapse before spraying	labor	
Obtain spray equipment	labor	
Turn spray on	labor	
Spray all cleaning solution from tank	labor	
Turn spray off	labor	
Operator opens control valve	\$/cleanup	\$1.00
Find correct control valve	labor	
Open valve	labor	
Water goes to treatment facility	\$/cleanup	\$2.75
Wait for water to drain	labor	
Operator closes control valve	\$/cleanup	\$1.00
Locate correct control valve	labor	
Close valve	labor	
Total =	\$per testing	\$67.00

Activities Associated with Sampling and Testing

Activity Description	Cost Driver	Cost/Activity
Get sample	\$/testing	\$1.35
Go to the line	labor	
Titrate small sample into flask	labor	
	materials	
Transfer to lab	labor	
Test sample	\$/testing	\$1.35
Request testing chemicals	labor	
Document request	labor	
Locate chemicals	labor	
Add chemicals to sample	labor	
	materials	
Mix	labor	
Document the results	labor	
Return testing chemicals	labor	
Relay information to line operator	\$/testing	\$1.00
Return to line	labor	
Inform operator of results	labor	
Document	labor	
Total =	\$per testing	\$3.70

Activities Associated with Filter Replacement

Activity Description	Cost Driver	Cost/Activity
Check old filter	\$/replacement	\$1.50
Pull canister from process	labor	
Inspect filter	labor	
Decide if replacement is necessary	labor	
Get new filter	\$/replacement	\$1.75
Go to storage area	labor	
Locate new filters	labor	
Fill out paper work	labor	
Return to tank	labor	
Change filter	\$/replacement	\$12.25
Pull old filter from canister	labor	
Replace with new filter	labor	
	filter	
Replace canister	labor	
Fill out paper work	labor	
Dispose of old filter	\$/replacement	\$2.00
Take old filter to disposal bin/area	labor	
Dispose of filter	labor	
Return to tank	labor	
Fill out paper work	labor	
Total =	\$per replacement	\$17.50

G.4 Simulation Model Outputs for MHC Alternatives

APPENDIX G

SIMAN V - License #8810427
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: VERTICAL GENERIC ELECTRO Run execution date : 6/10/1997
Analyst: CHAD TONEY Model revision date: 7/10/1996

Replication ended at time : 163453.0

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	45.201	.81575	34.000	306.00	3615
TIME IN SYSTEM	49.271	9.8667E-04	49.116	49.333	3616
TIME STOPPED	80.408	.69205	.00000	271.97	422

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
CARRIER Active	15.000	.00000	15.000	15.000	15.000
CARRIER Busy	.01106	9.4553	.00000	1.0000	.00000
# in ACCELERATOR_Q	.00148	26.015	.00000	1.0000	.00000
# in ACID DIP_Q	.00147	26.019	.00000	1.0000	.00000
# in CATALYST_Q	.00148	26.015	.00000	1.0000	.00000
# in CLEAN_Q	8.3941E-04	34.500	.00000	1.0000	.00000
# in ELECTROLESS_Q	.00192	22.819	.00000	1.0000	.00000
# in MICROETCH_Q	.00148	26.015	.00000	1.0000	.00000
# in PREDIP_Q	.00148	26.015	.00000	1.0000	.00000
# in RINSE1_Q	.00148	26.015	.00000	1.0000	.00000
# in RINSE2_Q	.00148	26.015	.00000	1.0000	.00000
# in RINSE3_Q	.00148	26.015	.00000	1.0000	.00000
# in RINSE4_Q	.00148	25.999	.00000	1.0000	.00000
# in RINSE5_Q	.00147	26.019	.00000	1.0000	.00000
# in RINSE6_Q	.00147	26.019	.00000	1.0000	.00000
# in RINSE7_Q	.00147	26.019	.00000	1.0000	.00000
# in STARTING_Q	.00000	--	.00000	.00000	.00000
# in TARNISH_Q	.00147	26.019	.00000	1.0000	.00000
# in CLEAN1_Q	.00000	--	.00000	.00000	.00000
# in MICROETCH1_Q	.00000	--	.00000	.00000	.00000
# in PREDIP1_Q	.00000	--	.00000	.00000	.00000
# in CATALYST1_Q	.00000	--	.00000	.00000	.00000
# in ACCELERATOR1_Q	.00000	--	.00000	.00000	.00000
# in ELECTROLESS1_Q	.00000	--	.00000	.00000	.00000
# in ACID DIP1_Q	.00000	--	.00000	.00000	.00000
# in TARNISH1_Q	.00000	--	.00000	.00000	.00000

COUNTERS

Identifier	Count	Limit
PARTS DONE	3616	Infinite

FREQUENCIES

Identifier	Category	--Occurrences--		Standard Percent	Restricted Percent
		Number	AvgTime		
STATE (CLEAN1_R)	CLEAN BATH	9	138.22	0.76	0.76
	BUSY	400	92.965	22.75	22.75
	IDLE	403	310.23	76.49	76.49
STATE (MICROETCH1_R)	MICRO BATH	18	145.66	1.60	1.60
	BUSY	400	94.395	23.10	23.10
	IDLE	405	303.88	75.30	75.30
STATE (PREDIP1_R)	PREDIP BATH	8	124.50	0.61	0.61
	BUSY	400	95.790	23.44	23.44
	IDLE	402	308.80	75.95	75.95
STATE (CATALYST1_R)	CATAL BATH	1	230.00	0.14	0.14
	BUSY	400	95.485	23.37	23.37
	IDLE	401	311.79	76.49	76.49
STATE (ACCELERATOR1_R)	ACCEL BATH	16	129.75	1.27	1.27
	BUSY	400	97.560	23.87	23.87
	IDLE	405	302.10	74.86	74.86
STATE (ELECTROLESS1_R)	ELECT BATH	10	113.60	0.70	0.70
	BUSY	400	98.875	24.20	24.20
	IDLE	401	306.15	75.11	75.11
STATE (ACID DIP1_R)	ACID BATH	6	146.00	0.54	0.54
	BUSY	400	99.445	24.34	24.34
	IDLE	401	306.23	75.13	75.13
STATE (TARNISH1_R)	TARN BATH	13	119.53	0.95	0.95
	BUSY	400	101.42	24.82	24.82
	IDLE	404	300.31	74.23	74.23

Execution time: 75.62 minutes.
Simulation run complete.

APPENDIX G

SIMAN V - License #8810427
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: TYPICAL CARBON CONVEYORIZED
Analyst: CHAD TONEY

Run execution date : 10/ 4/1996
Model revision date: 7/11/1996

Replication ended at time 50808.6

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	.81854	6.7748	.60608	195.00	62056
TIME IN SYSTEM	47.610	1.0902	12.996	257.69	62057
TIME STOPPED	74.507	1.0634	14.000	208.92	158

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
# in TO_CLEANER_Q	.00145	26.200	.00000	1.0000	.00000

COUNTERS

Identifier	Count	Limit
parts done	62057	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE(CLEAN_R)	CLEAN BATH	26	147.01	7.52	7.52
	BUSY	124	12.460	3.04	3.04
	IDLE	136	334.12	89.44	89.44
STATE(MICROETCH_R)	MICRO BATH	21	160.66	6.64	6.64
	BUSY	124	24.645	6.01	6.01
	IDLE	138	321.58	87.34	87.34
STATE(CARBON_R)	BUSY	124	12.460	3.04	3.04
	IDLE	125	394.10	96.96	96.96
STATE(CONDITIONER_R)	CONDI BATH	20	142.03	5.59	5.59
	BUSY	124	19.674	4.80	4.80
	IDLE	134	339.76	89.61	89.61
STATE(CARBON2_R)	BUSY	124	19.674	4.80	4.80
	IDLE	125	386.95	95.20	95.20

Execution time: 32.93 minutes.

SIMAN V - License #8810427
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: CONVEYORIZED TYPICAL CON Run execution date : 6/11/1997
Analyst: CHAD TONEY Model revision date: 7/10/1996

Replication ended at time : 29091.1

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	.46866	9.1628	.35294	190.00	62056
TIME IN SYSTEM	38.993	1.2748	8.0000	216.01	62057
TIME STOPPED	77.321	.99426	.00000	192.20	92

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
# in TO_MICROETCHER_Q	.36856	1.3089	.00000	1.0000	1.0000

COUNTERS

Identifier	Count	Limit
PARTS DONE	62057	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE(CLEAN_R)	CLEAN BATH	13	150.96	6.75	6.75
	BUSY	71	21.147	5.16	5.16
	IDLE	78	328.55	88.09	88.09
STATE(MICROETCH_R)	MICRO BATH	21	145.76	10.52	10.52
	BUSY	71	15.567	3.80	3.80
	IDLE	82	303.96	85.68	85.68
STATE(CATALYST_R)	BUSY	71	21.147	5.16	5.16
	IDLE	72	383.18	94.84	94.84
STATE(CONDUCT_R)	CONDUCT BATH	6	135.43	2.79	2.79
	BUSY	71	24.971	6.09	6.09
	IDLE	75	353.40	91.11	91.11
STATE(MICROETCH2_R)	MICRO2 BATH	21	145.76	10.52	10.52
	BUSY	71	24.971	6.09	6.09
	IDLE	82	295.81	83.38	83.38
STATE(CLEAN2_R)	CLEAN2 BATH	13	150.96	6.75	6.75
	BUSY	71	21.147	5.16	5.16
	IDLE	78	328.55	88.09	88.09

Execution time: 25.02 minutes.
Simulation run complete.

APPENDIX G

SIMAN V - License #8810427
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: CONVEYORIZED GENERIC ELE
Analyst: CHAD TONEY

Run execution date : 6/10/1997
Model revision date: 7/ 9/1996

Replication ended at time : 36063.0

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	.58089	11.492	.31433	195.00	62056
TIME IN SYSTEM	52.938	1.1157	14.998	282.95	62057
TIME STOPPED	114.06	.69924	.00000	211.27	143

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
# in TO_CLEANER_Q	.00259	19.641	.00000	1.0000	.00000

COUNTERS

Identifier	Count	Limit
PARTS DONE	62057	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE(ACCELERATOR_R)	ACCEL BATH	15	160.23	6.66	6.66
	BUSY	88	29.890	7.29	7.29
	IDLE	95	326.62	86.04	86.04
STATE(CLEAN_R)	CLEAN BATH	10	168.71	4.68	4.68
	BUSY	88	11.362	2.77	2.77
	IDLE	96	347.66	92.55	92.55
STATE(ELECTROLESS_R)	ELECT BATH	4	135.81	1.51	1.51
	BUSY	88	32.154	7.85	7.85
	IDLE	91	359.23	90.65	90.65
STATE(ACID DIP_R)	ACID BATH	6	174.40	2.90	2.90
	BUSY	88	33.135	8.09	8.09
	IDLE	91	352.75	89.01	89.01
STATE(MICROETCH_R)	MICRO BATH	21	165.74	9.65	9.65
	BUSY	88	16.644	4.06	4.06
	IDLE	102	305.07	86.29	86.29

STATE(CATALYST_R)	BUSY	88	25.024	6.11	6.11
	IDLE	89	380.45	93.89	93.89
STATE(PREDIP_R)	PREDIP BATH	13	126.76	4.57	4.57
	BUSY	88	25.024	6.11	6.11
	IDLE	93	346.37	89.32	89.32
STATE(TARNISH_R)	TARN BATH	28	146.91	11.41	11.41
	BUSY	88	45.458	11.09	11.09
	IDLE	100	279.48	77.50	77.50

Execution time: 35.08 minutes.
Simulation run complete.

APPENDIX G

SIMAN V - License #9999999
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: GRAPHITE CONVEYORIZED Run execution date : 10/ 7/1996
Analyst: CHAD TONEY Model revision date: 7/11/1996

Replication ended at time : 33441.3

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	.53876	8.2863	.43032	230.00	62056
TIME IN SYSTEM	50.811	1.3392	7.7983	262.99	62057
TIME STOPPED	66.957	1.3307	10.000	230.00	97

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
KNIFE_R Available	1.0000	.00000	1.0000	1.0000	1.0000
KNIFE_R Busy	.00000	--	.00000	1.0000	.00000
# in TO_CLEANER_Q	.05939	3.9795	.00000	1.0000	.00000

COUNTERS

Identifier	Count	Limit
PARTS DONE	62057	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE (CLEAN_R)	CLEAN BATH	11	146.08	4.81	4.81
	BUSY	81	13.067	3.17	3.17
	IDLE	85	362.06	92.03	92.03
STATE (MICROETCH_R)	MICRO BATH	21	169.72	10.66	10.66
	BUSY	81	29.377	7.12	7.12
	IDLE	93	295.67	82.23	82.23
STATE (GRAPHITE_R)	GRAPH BATH	3	171.19	1.54	1.54
	BUSY	81	14.975	3.63	3.63
	IDLE	83	382.10	94.84	94.84

Execution time: 19.63 minutes.
Simulation run complete.

SIMAN V - License #8810427
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: VERTICAL NONFORMALDEHYDE
Analyst: CHAD TONEY

Run execution date : 7/ 1/1997
Model revision date: 5/13/1996

Replication ended at time : 73313.7

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	20.266	.81589	15.900	160.00	3615
TIME IN SYSTEM	49.864	.04022	49.600	66.400	3616
TIME STOPPED	62.084	.24716	.00000	127.82	243

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
ACCELERATOR_R Available	1.0000	.00000	1.0000	1.0000	1.0000
ACCELERATOR_R Busy	.12334	2.6660	.00000	1.0000	.00000
CLEAN_R Available	1.0000	.00000	1.0000	1.0000	1.0000
CLEAN_R Busy	.12340	2.6653	.00000	1.0000	1.0000
ACTIVATOR_R Available	1.0000	.00000	1.0000	1.0000	1.0000
ACTIVATOR_R Busy	.12337	2.6656	.00000	1.0000	.00000
ELECTROLESS_R Available	1.0000	.00000	1.0000	1.0000	1.0000
ELECTROLESS_R Busy	.77594	.53736	.00000	1.0000	1.0000
FLASH_R Available	1.0000	.00000	1.0000	1.0000	1.0000
FLASH_R Busy	.12331	2.6664	.00000	1.0000	.00000
MICROETCH_R Available	1.0000	.00000	1.0000	1.0000	1.0000
MICROETCH_R Busy	.12337	2.6656	.00000	1.0000	.00000
POSTDIP_R Available	1.0000	.00000	1.0000	1.0000	1.0000
POSTDIP_R Busy	.12337	2.6656	.00000	1.0000	1.0000
PREDIP_R Available	1.0000	.00000	1.0000	1.0000	1.0000
PREDIP_R Busy	.12337	2.6656	.00000	1.0000	.00000
RINSE1_R Available	1.0000	.00000	1.0000	1.0000	1.0000
RINSE1_R Busy	.12337	2.6656	.00000	1.0000	.00000
RINSE2_R Available	1.0000	.00000	1.0000	1.0000	1.0000
RINSE2_R Busy	.12337	2.6656	.00000	1.0000	.00000
RINSE3_R Available	1.0000	.00000	1.0000	1.0000	1.0000
RINSE3_R Busy	.12334	2.6660	.00000	1.0000	.00000
RINSE4_R Available	1.0000	.00000	1.0000	1.0000	1.0000
RINSE4_R Busy	.12334	2.6660	.00000	1.0000	.00000
TARNISH_R Available	1.0000	.00000	1.0000	1.0000	1.0000
TARNISH_R Busy	.12331	2.6664	.00000	1.0000	.00000
RINSE5_R Available	1.0000	.00000	1.0000	1.0000	1.0000
RINSE5_R Busy	.12331	2.6664	.00000	1.0000	.00000
CARRIER Active	15.000	.00000	15.000	15.000	15.000
CARRIER Busy	.02566	6.1618	.00000	1.0000	.00000
POSTDIP1_R Available	1.0000	.00000	1.0000	1.0000	1.0000
POSTDIP1_R Busy	.00000	--	.00000	1.0000	.00000

COUNTERS

APPENDIX G

Identifier		Count	Limit		
PARTS DONE		3616	Infinite		
FREQUENCIES					
Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE (ACCELERATOR1_R)	ACCEL BATH	16	81.000	1.77	1.77
	BUSY	179	65.391	15.97	15.97
	IDLE	193	312.50	82.27	82.27
STATE (ACTIVATOR1_R)	BUSY	179	65.391	15.97	15.97
	IDLE	180	342.27	84.03	84.03
STATE (CLEAN1_R)	CLEAN BATH	9	66.314	0.81	0.81
	BUSY	179	65.100	15.89	15.89
	IDLE	186	328.30	83.29	83.29
STATE (ELECTROLESS1_R)	ELECT BATH	10	61.746	0.84	0.84
	BUSY	179	64.966	15.86	15.86
	IDLE	186	328.31	83.30	83.30
STATE (FLASH1_R)	FLASH BATH	6	81.000	0.66	0.66
	BUSY	179	65.491	15.99	15.99
	IDLE	184	332.09	83.35	83.35
STATE (MICROETCH1_R)	MICRO BATH	18	63.405	1.56	1.56
	BUSY	179	64.771	15.81	15.81
	IDLE	190	318.83	82.63	82.63
STATE (PREDIP1_R)	PREDIP BATH	8	64.491	0.70	0.70
	BUSY	179	65.391	15.97	15.97
	IDLE	186	328.45	83.33	83.33
STATE (TARNISH1_R)	TARN BATH	14	73.400	1.40	1.40
	BUSY	179	64.973	15.86	15.86
	IDLE	191	317.57	82.73	82.73

Execution time: 40.03 minutes.
Simulation run complete.

SIMAN V - License #9999999
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: TYPICAL ORGANIC PALLADIUM CONVEYORIZED Run execution date : 10/ 4/1996
Analyst: CHAD TONEY Model revision date: 7/11/1996

Replication ended at time : 45329.2

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	.73022	7.8793	.43504	232.76	62056
TIME IN SYSTEM	28.353	.92094	14.595	119.50	62057
TIME STOPPED	81.324	.63072	.00000	226.77	221

COUNTERS

Identifier	Count	Limit
PARTS DONE	62057	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE(CLEAN_R)	CLEAN BATH	39	103.56	8.91	8.91
	BUSY	111	21.517	5.27	5.27
	IDLE	137	283.95	85.82	85.82
STATE(MICROETCH_R)	MICRO BATH	21	103.68	4.80	4.80
	BUSY	111	24.406	5.98	5.98
	IDLE	126	320.97	89.22	89.22
STATE(CONDITIONER_R)	CONDI BATH	25	103.31	5.70	5.70
	BUSY	111	27.955	6.85	6.85
	IDLE	130	304.94	87.46	87.46
STATE(PREDIP_R)	PREDIP BATH	21	100.53	4.66	4.66
	BUSY	111	29.498	7.22	7.22
	IDLE	125	319.54	88.12	88.12
STATE(CONDUCT_R)	CONDUCT BATH	1	123.00	0.27	0.27
	BUSY	111	30.606	7.49	7.49
	IDLE	113	369.99	92.23	92.23
STATE(POSTDIP_R)	POSTDIP BATH	31	111.61	7.63	7.63
	BUSY	111	32.685	8.00	8.00
	IDLE	133	287.52	84.36	84.36
STATE(ACID DIP_R)	ACID BATH	21	105.90	4.91	4.91
	BUSY	111	35.369	8.66	8.66
	IDLE	128	306.08	86.43	86.43

Execution time: 35.07 minutes.
Simulation run complete.

APPENDIX G

SIMAN V - License #9999999
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: TYPICAL ORGANIC PALLADIUM VERTICAL
Analyst: CHAD TONEY

Run execution date : 9/26/1996
Model revision date: 7/11/1996

Replication ended at time : 31763.2

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	8.7786	2.1895	2.0750	226.95	3615
TIME IN SYSTEM	33.349	.44838	27.575	137.57	3616
TIME STOPPED	77.536	.53042	.02500	187.45	139

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
CARRIER Active	13.000	.00000	13.000	13.000	13.000
CARRIER Busy	.12964	2.6342	.00000	2.0000	.00000

COUNTERS

Identifier	Count	Limit
PARTS DONE	3616	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE(CLEAN1_R)	CLEAN BATH	23	91.783	6.65	6.65
	BUSY	77	40.221	9.75	9.75
	IDLE	94	282.50	83.60	83.60
STATE(CONDITIONER1_R)	CONDI BATH	18	89.387	5.07	5.07
	BUSY	77	41.871	10.15	10.15
	IDLE	90	299.22	84.78	84.78
STATE(PREDIP1_R)	PREDIP BATH	14	90.642	4.00	4.00
	BUSY	77	42.793	10.37	10.37
	IDLE	88	309.08	85.63	85.63
STATE(CONDUCTOR1_R)	CONDUCT BATH	2	65.158	0.41	0.41
	BUSY	77	44.891	10.88	10.88
	IDLE	79	356.66	88.71	88.71
STATE(POSTDIP1_R)	POSTDIP BATH	18	101.21	5.74	5.74
	BUSY	77	43.271	10.49	10.49
	IDLE	90	295.65	83.77	83.77
STATE(ACID DIP1_R)	ACID BATH	22	91.494	6.34	6.34
	BUSY	77	46.718	11.33	11.33
	IDLE	95	275.29	82.34	82.34
STATE(MICROETCH1_R)	MICRO BATH	18	91.800	5.20	5.20
	BUSY	77	40.355	9.78	9.78
	IDLE	91	296.74	85.01	85.01

Execution time: 26.28 minutes.
Simulation run complete.

SIMAN V - License #8810427
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: CONVEYORIZED GENERIC TIN
Analyst: CHAD TONEY

Run execution date : 6/10/1997
Model revision date: 7/11/1996

Replication ended at time : 26082.6

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	.42017	11.661	.27134	190.00	62056
TIME IN SYSTEM	64.169	1.1194	8.6078	433.99	62057
TIME STOPPED	93.815	.90075	10.000	241.52	96

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
# in TO_CLEANER_Q	.03874	4.9813	.00000	1.0000	.00000

COUNTERS

Identifier	Count	Limit
PARTS DONE	62057	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE(CLEAN_R)	CLEAN BATH	9	181.61	6.27	6.27
	BUSY	63	4.9883	1.20	1.20
	IDLE	71	339.91	92.53	92.53
STATE(MICROETCH_R)	MICRO BATH	21	129.85	10.45	10.45
	BUSY	63	23.525	5.68	5.68
	IDLE	76	287.81	83.86	83.86
STATE(PREDIP_R)	PREDIP BATH	15	149.46	8.60	8.60
	BUSY	63	32.337	7.81	7.81
	IDLE	72	302.82	83.59	83.59
STATE(ACID DIP_R)	ACID BATH	7	122.88	3.30	3.30
	BUSY	63	42.546	10.28	10.28
	IDLE	64	352.21	86.43	86.43
STATE(CATALYST_R)	BUSY	63	32.337	7.81	7.81
	IDLE	64	375.70	92.19	92.19
STATE(ACCELERATOR_R)	ACCEL BATH	7	153.10	4.11	4.11
	BUSY	63	35.931	8.68	8.68
	IDLE	68	334.51	87.21	87.21

Execution time: 23.80 minutes.
Simulation run complete.

APPENDIX G

SIMAN V - License #8810427
Systems Modeling Corporation

Summary for Replication 1 of 1

Project: VERTICAL GENERIC TIN STA
Analyst: CHAD TONEY

Run execution date : 6/10/1997
Model revision date: 7/11/1996

Replication ended at time : 48525.4

TALLY VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Observations
TAKT TIME	13.409	1.9911	9.2750	294.97	3615
TIME IN SYSTEM	52.839	.08080	50.000	65.625	3616
TIME STOPPED	102.49	.73478	.00000	286.32	133

DISCRETE-CHANGE VARIABLES

Identifier	Average	Variation	Minimum	Maximum	Final Value
CARRIER Active	11.000	.00000	11.000	11.000	11.000
CARRIER Busy	.06573	3.8295	.00000	2.0000	.00000

COUNTERS

Identifier	Count	Limit
PARTS DONE	3616	Infinite

FREQUENCIES

Identifier	Category	--Occurrences-- Number	AvgTime	Standard Percent	Restricted Percent
STATE(CLEAN1_R)	CLEAN BATH	7	170.93	2.47	2.47
	BUSY	119	63.565	15.59	15.59
	IDLE	121	328.63	81.95	81.95
STATE(MICROETCH1_R)	MICRO BATH	18	202.66	7.52	7.52
	BUSY	119	63.707	15.62	15.62
	IDLE	127	293.67	76.86	76.86
STATE(PREDIP1_R)	PREDIP BATH	10	67.055	1.38	1.38
	BUSY	119	75.149	18.43	18.43
	IDLE	120	324.26	80.19	80.19
STATE(CATALYST1_R)	BUSY	119	75.149	18.43	18.43
	IDLE	119	332.62	81.57	81.57
STATE(ACCELERATOR1_R)	ACCEL BATH	7	107.83	1.56	1.56
	BUSY	119	74.082	18.17	18.17
	IDLE	125	311.63	80.28	80.28
STATE(ACID DIP1_R)	ACID BATH	8	159.12	2.62	2.62
	BUSY	119	77.569	19.02	19.02
	IDLE	121	314.22	78.35	78.35

Execution time: 36.25 minutes.
Simulation run complete.

G.5 Chemical Costs by Bath for Individual MHC Processes

Total Materials Cost by MHC Alternative

APPENDIX G**Process: Electroless Copper****Supplier #1**

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	75.3	A	6	\$25.45/gal	\$98.79	\$114.98
Microetch	64.3	75.3	B	13.8 g/l	\$2.57/lb	\$50.27	\$58.87
			C	2.5	7.62/gal		
			D	18.5	\$1.60/gal		
Predip	49.8	75.3	E	31.725 g/l	\$1.31/lb	\$14.65	\$22.15
			F	1.5	\$2.00/gal		
Catalyst	138.5	75.3	G	4	\$391.80/gal	\$2,180.53	\$1,185.52
			H	0.176 g/l	\$1.31/lb		
			I	3.5	\$2.00/gal		
Accelerator	79.5	75.3	J	20	\$18.10/gal	\$287.79	\$272.59
Electroless Copper	185	75.3	K	7	\$27.60/gal	\$617.92	\$251.51
			L	8.5	\$16.45/gal		
			M	0.22	\$4.50/gal		
Neutralizer	57	75.3	N	100	\$1.60/gal	\$91.20	\$120.48
Anti-Tarnish	38.6	75.3	O	0.25	\$39.00/gal	\$3.76	\$7.33

Process: Electroless Copper**Supplier #2**

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	75.3	A	6	\$25.45/gal	\$98.79	\$114.98
Microetch	64.3	75.3	B	13.8 g/l	\$2.57/lb	\$50.27	\$58.87
			C	2.5	7.62/gal		
			D	18.5	\$1.60/gal		
Predip	49.8	75.3	E	31.725 g/l	\$1.31/lb	\$14.65	\$22.15
			F	1.5	\$2.00/gal		
Catalyst	138.5	75.3	G	4	\$391.80/gal	\$2,180.53	\$1,185.52
			H	0.176 g/l	\$1.31/lb		
			I	3.5	\$2.00/gal		
Accelerator	79.5	75.3	J	20	\$18.10/gal	\$287.79	\$272.59
Electroless Copper	185	75.3	K	2.75	\$27.60/gal	\$623.45	\$253.76
			L	1.75	\$12.90/gal		
			M	14.5	\$16.45/gal		
Neutralizer	57	75.3	N	100	\$1.60/gal	\$91.20	\$120.48
Anti-Tarnish	38.6	75.3	O	0.25	\$39.00/gal	\$3.76	\$7.33

Process: Electroless Copper
Supplier #3

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	75.3	A	10	\$36.68/gal	\$356.00	\$414.32
			B	5	\$28.78/gal		
			C	2.5	\$15.81/gal		
Microetch	64.3	75.3	D	9.8 g/l	\$2.62/lb	\$16.32	\$19.11
			E	2.5	\$1.60/gal		
Predip	49.8	75.3	F	75	\$5.39/gal	\$201.32	\$304.41
Activator/Palladium	57	75.3	G	1	\$497.71/gal	\$514.12	\$679.18
			H	75	\$5.39/gal		
Accelerator	79.5	75.3	I	8.96 g/l	\$497.71/lb	\$3,013.94	\$2,854.71
			J	1	\$77.71/gal		
Electroless Copper	185	75.3	K	4	\$11.51/gal	\$433.14	\$176.30
			L	10	\$15.44		
			M	0.2	\$19.36/gal		
			N	3	\$9.19/gal		
			O	0.5	\$4.50/gal		
Anti-Tarnish	38.6	75.3	P	1	\$28.26/gal	\$10.90	\$21.26

Process: Electroless Copper
Supplier #4

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	75.3	A	12.5	\$10.30/gal	\$83.30	\$96.95
Microetch	64.3	75.3	B	5	\$12.32/gal	\$84.68	\$95.65
			C	3	\$13.81/gal		
			D	15	\$1.60/gal		
Predip	49.8	75.3	E	75	\$2.79/gal	\$104.21	\$157.57
Activator/Palladium	57	75.3	F	3.8	\$211.35/gal	\$638.35	\$843.29
			G	1	\$128.59/gal		
			H	579.5 g/l	\$0.39/lb		
Accelerator	79.5	75.3	I	5	\$16.47/gal	\$144.65	\$137.01
			J	15	\$6.64/gal		
Electroless Copper	185	75.3	K	5	\$9.57/gal	\$393.16	\$160.03
			L	1.5	\$9.22/gal		
			M	12	\$12.57/gal		
Acid Dip	78.8	75.3	N				
Anti-Tarnish	38.6	75.3	O	0.25	\$14.07	\$1.36	\$2.65

APPENDIX G**Process: Electroless Copper
Supplier #5**

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	75.3	A	15	\$26.50/gal	\$257.18	\$299.31
Microetch	64.3	75.3	B	60 g/l	\$2.57/lb	\$83.59	\$97.89
			C	1	\$1.60/gal		
Predip	49.8	75.3	D	1165 g/l	\$1.59/gal	\$768.14	\$1,161.46
Palladium Catalyst	138.5	75.3	E	3	\$497/gal	\$2,280.00	\$1,239.60
			F	97	\$1.59/lb		
Electroless Copper	185	75.3	G	4.2	\$19.29/gal	\$1,834.31	\$746.61
			H	10	\$29.37/gal		
			I	12	\$51.40/gal		
Anti-Tarnish	38.6	75.3	J	2.5	\$20.50/gal	\$21.63	\$42.20
			K	3	\$1.60/gal		

**Process: Electroless Copper
Supplier #6**

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	75.3	A	0.5	\$22.70/gal	\$77.87	\$90.63
			B	4	\$26.88/gal		
			C	2.5	\$0.594/g		
Predip	49.8	75.3	D	5	\$99.29/gal	\$247.22	\$373.81
Activator	57	75.3	E	25	\$147.5/gal	\$2,101.89	\$2,776.71
			F	0.5	\$0.0594/g		
Reducer	57	75.3	G	0.5	\$147.5/gal	\$42.03	\$55.52
			H	5 g/l	\$.795/lb		
Electroless Copper	185	75.3	I	1.4	No data		
			J	8	No data		
			K	0.15	No data		
			L	3	No data		

Process: Formaldehyde-Free Electroless Copper
Supplier #1

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	No data	75.3	A	10	\$36.68/gal	No data	\$384.56
			B	5	\$28.78/gal		
Microetch	No data	75.3	C	9.8 g/l	\$2.62/lb	No data	\$19.11
			D	2.5	\$1.60/gal		
Predip	No data	75.3	E	75	\$6.38/gal	No data	\$360.31
Activator	No data	75.3	F	1.5	\$497.71/gal	No data	\$562.17
			G	75	\$6.38/gal		
Accelerator	No data	75.3	H	8.96 g/l	\$497.71/gal	No data	\$2,854.70
			I	1	\$77.71/gal		
Electroless Copper	No data	75.3	J	11	\$92.96/gal	No data	\$1,633.84
			K	5.5	\$14.18/gal		
			L	32	\$24.99/gal		
			M	25 g/l	\$5.49/lb		
			N	15 g/l	\$12.43/lb		
Anti-Tarnish	No data	75.3	O	1	\$28.61/gal	No data	\$21.54

Process: Organic-Palladium
Supplier #1

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner	44	75.3	A	5	\$36.38/gal	\$104.95	\$180.45
			B	5	\$11.55/gal		
Microetch	64.3	75.3	C	75 g/l	\$16.20/gal	\$650.54	\$761.83
Predip	49.8	75.3	D	100	No data	No data	No data
Conductor	108	75.3	E	10	\$36.38/gal	\$534.6	\$372.74
			F	10	\$13.12/gal		
Post-Dip	45	75.3	G	20	\$17.42/gal	\$156.78	\$262.35
Acid Dip Bath	78.8	75.3	H	No data	No data	No data	No data
Conditioner	56	75.3	I	5	\$36.38/gal	\$133.58	\$180.45
			J	5	\$11.55/gal		

APPENDIX G**Process: Tin-Palladium****Supplier #1**

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	75.3	A	25	\$22.90/gal	\$370.41	\$431.10
Microetch	64.3	75.3	B	149.8 g/l	\$3/lb	\$241.14	\$282.39
			C	0.5	\$1.60/gal		
Predip	49.8	75.3	D	100	\$12.75/gal	\$634.95	\$960.08
Activator	138.5	75.3	E	95	\$12.75/gal	\$6,871.33	\$3,735.82
			F	5	\$750/gal		
Accelerator	79.5	75.3	G	25	\$13.20/gal	\$724.44	\$686.17
			H	25	\$23.25/gal		
Acid Dip Bath	78.8	75.3	I	10	\$1.60/gal	\$12.61	\$12.05

Process: Tin-Palladium**Supplier #2**

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Conditioner	55.7	75.3	A	15	\$31.38/gal	\$292.13	\$394.93
			B	2.5	\$21.58/gal		
Predip	49.8	75.3	C	100	\$5.94/gal	\$295.18	\$447.28
Palladium Catalyst	138.5	75.3	D	92	\$5.94/gal	\$5,411.36	\$2,942.06
			E	8	\$420.80/gal		
Accelerator	79.5	75.3	F	20	\$68.75/gal	\$1,093.12	\$1,035.37
Enhancer	57	75.3	G	2	\$5.14/gal	\$25.81	\$34.10
			H	2	\$17.50/gal		
Stabilizer	57	75.3	I	2	\$17.50/gal	\$19.95	\$26.36
Microetch	64.3		J	7	\$25.79/gal	\$318.13	\$372.55
			K	2.5	\$104.29/gal		
			L	10	\$1.60/gal		
			M	5	\$7.50/gal		

Process: Tin-Palladium**Supplier #3**

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Conditioner	55.7	75.3	A	1	\$83.30/gal	\$46.40	\$62.73
Microetch	64.3	75.3	B	175 g/l	\$1.50/lb	\$140.55	\$164.59
Predip	49.8	75.3	C	100	\$2.95/gal	\$209.35	\$316.55
Catalyst	138.5	75.3	D	95	\$5.95/gal	\$6,634	\$3,607.00
			E	5	\$845/gal		
Accelerator	79.5	75.3	F	0.045 g/l	No data	No data	No data
			G	1.2			
Acid Stabilizer	78.8	75.3	H	10	\$1.60/gal	\$12.61	\$12.05

Process: Carbon
Supplier #1

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner	44	No data	A	5	\$90.43/gal	\$198.94	No data
Conditioner	55.7	No data	B	2.5	\$192.17/lb	\$267.60	No data
Carbon Black	128	No data	C	100	\$153.98/gal	\$19,709.44	No data
Microetch	64.3	No data	D	200 g/l	\$1.17/lb	\$126.03	No data
			E	1	\$1.60/gal		

Process: Graphite
Supplier #1

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Cleaner/Conditioner	64.7	No data	A	25	\$47.83/gal	\$773.66	No data
Graphite	36.5	No data	B	60	\$675/gal	\$14,782.50	No data
Fixer	57	No data	C	10	\$16.50/gal	\$94.05	No data
Microetch	64.3	No data	D	55	\$9.32/gal	\$331.66	No data
			E	2	\$1.60/gal		

Process: Conductive Polymer
Supplier #1

Bath	Volume in Bath (in gallons) Horizontal	Volume in Bath (in gallons) Vertical	Chemical Name	Percentage of Chemical in Bath	Cost of Chemicals	Total Cost of the Bath (Horizontal)	Total Cost of the Bath (Vertical)
Microetch	64.3	No data	A	2	\$1.60/gal	\$27.64	No data
		No data	B	7.5 Kg	\$3.41/Kg		No data
Cleaner/Conditioner	64.7	No data	C	10	\$21.90/gal	\$140.82	No data
Catalyst	138.5	No data	D	81.5	\$36.90/gal	\$4,183.90	No data
		No data	E	0.3	\$4.00/gal		No data
		No data	F	0.5	\$24.60/gal		No data
Conductive Polymer	26	No data	G	15	\$90.30/gal	\$460.70	No data
		No data	H	23	\$17.40/gal		No data
		No data	I	0.7	\$24.60/gal		No data

Summary average cost per bath

Process: Electroless Copper

Bath	Total Bath Cost (Conveyorized)	Replacement Frequency (Conveyorized)	Annual Cost (Conveyorized)	Total Bath Cost (Non-Conveyorized)	Replacement Frequency (Non-Conveyorized)	Annual Cost (Non-Conveyorized)
Cleaner/ Conditioner	\$161.99	10	\$1,619.90	\$188.53	9	\$1,696.77
Microetch	\$57.03	21	\$1,197.63	\$66.08	18	\$1,189.44
Predip	\$225.03	13	\$2,925.39	\$340.26	8	\$2,722.08
Catalyst	\$1,649.24	1	\$1,649.24	\$1,318.30	1	\$1,318.30
Accelerator	\$755.24	15	\$11,328.60	\$718.48	16	\$11,495.68
Electroless Copper	\$779.29	4	\$3,117.16	\$317.19	10	\$3,171.90
Neutralizer	\$91.20	6	\$547.20	\$120.48	6	\$722.88
Anti-Tarnish	\$9.41	28	\$263.48	\$16.15	13	\$209.95
Total			\$22,648.60			\$22,527.00

Process: Formaldehyde-Free Electroless Copper

Bath	Total Bath Cost (Conveyorized)	Replacement Frequency (Conveyorized)	Annual Cost (Conveyorized)	Total Bath Cost (Non-Conveyorized)	Replacement Frequency (Non-Conveyorized)	Annual Cost (Non-Conveyorized)
Cleaner/ Conditioner	NA	NA	NA	\$384.56	9	\$3,461.04
Microetch	NA	NA	NA	\$19.11	18	\$343.98
Predip	NA	NA	NA	\$360.31	8	\$2,882.48
Activator	NA	NA	NA	\$562.17	1	\$562.17
Accelerator	NA	NA	NA	\$2,854.70	16	\$45,675.20
Electroless Copper	NA	NA	NA	\$1,633.84	10	\$16,338.40
Anti-Tarnish	NA	NA	NA	\$21.54	14	\$301.56
Total						\$69,564.83

Process: Organic Palladium

Bath	Total Bath Cost (Conveyorized)	Replacement Frequency (Conveyorized)	Annual Cost (Conveyorized)	Total Bath Cost (Non-Conveyorized)	Replacement Frequency (Non-Conveyorized)	Annual Cost (Non-Conveyorized)
Cleaner	\$155.05	39	\$6,046.95	\$180.45	23	\$4,150.35
Microetch	\$650.54	21	\$13,661.34	\$761.83	18	\$13,714.74
Conditioner	\$133.58	25	\$3,339.50	\$180.45	18	\$3,248.10
Predip	-	21	-	-	14	-
Conductor	\$534.60	1	\$534.60	\$372.74	2	\$745.48
Post Dip	\$156.78	31	\$4,860.18	\$262.35	18	\$4,722.30
Acid Dip Bath	\$19.95	21	\$418.95	\$19.02	22	\$418.34
Total			\$28,861.52			\$26,999.31

*Acid Dip assumed to be similar in price to acid dip for tin palladium.

Process: Tin-Palladium

Bath	Total Bath Cost (Conveyorized)	Replacement Frequency (Conveyorized)	Annual Cost (Conveyorized)	Total Bath Cost (Non-Conveyorized)	Replacement Frequency (Non-Conveyorized)	Annual Cost (Non-Conveyorized)
Cleaner/ Conditioner	\$236.31	9	\$2,126.79	\$296.25	7	\$2,073.75
Microetch	\$233.27	21	\$4,898.67	\$273.18	18	\$4,917.24
Predip	\$380.04	15	\$5,700.60	\$574.61	10	\$5,746.10
Catalyst	\$6,305.56	1	\$6,305.56	\$3,428.29	1	\$3,428.29
Accelerator	\$908.78	7	\$6,361.46	\$860.77	7	\$6,025.39
Acid Dip Bath	\$15.06	7	\$105.42	\$16.82	8	\$134.56
Total			\$25,498.50			\$22,325.33

* Some processes included an enhancer bath that will not be included in analysis.

Process: Carbon

Bath	Total Bath Cost (Conveyorized)	Replacement Frequency (Conveyorized)	Annual Cost (Conveyorized)	Total Bath Cost (Non-Conveyorized)	Replacement Frequency (Non-Conveyorized)	Annual Cost (Non-Conveyorized)
Cleaner	\$198.94	26	\$5,172.44	NA	NA	NA
Conditioner	\$267.60	20	\$5,352.00	NA	NA	NA
Carbon Black ¹	\$19,709.44	1	\$19,709.44	NA	NA	NA
Microetch	\$126.03	21	\$2,646.63	NA	NA	NA
Total			\$32,880.51	NA	NA	NA

¹ Carbon had no bath replacements in the simulation, however, at least one bath out of two would more than likely have been replaced.

Process: Graphite

Bath	Total Bath Cost (Conveyorized)	Replacement Frequency (Conveyorized)	Annual Cost (Conveyorized)	Total Bath Cost (Non-Conveyorized)	Replacement Frequency (Non-Conveyorized)	Annual Cost (Non-Conveyorized)
Cleaner/Conditioner	\$773.66	11	\$8,510.26	NA	NA	NA
Graphite	\$14,782.50	3	\$44,347.50	NA	NA	NA
Fixer	\$94.05	NA	NA	NA	NA	NA
Microetch	\$331.66	21	\$6,964.86	NA	NA	NA
Total			\$59,822.62	NA	NA	NA

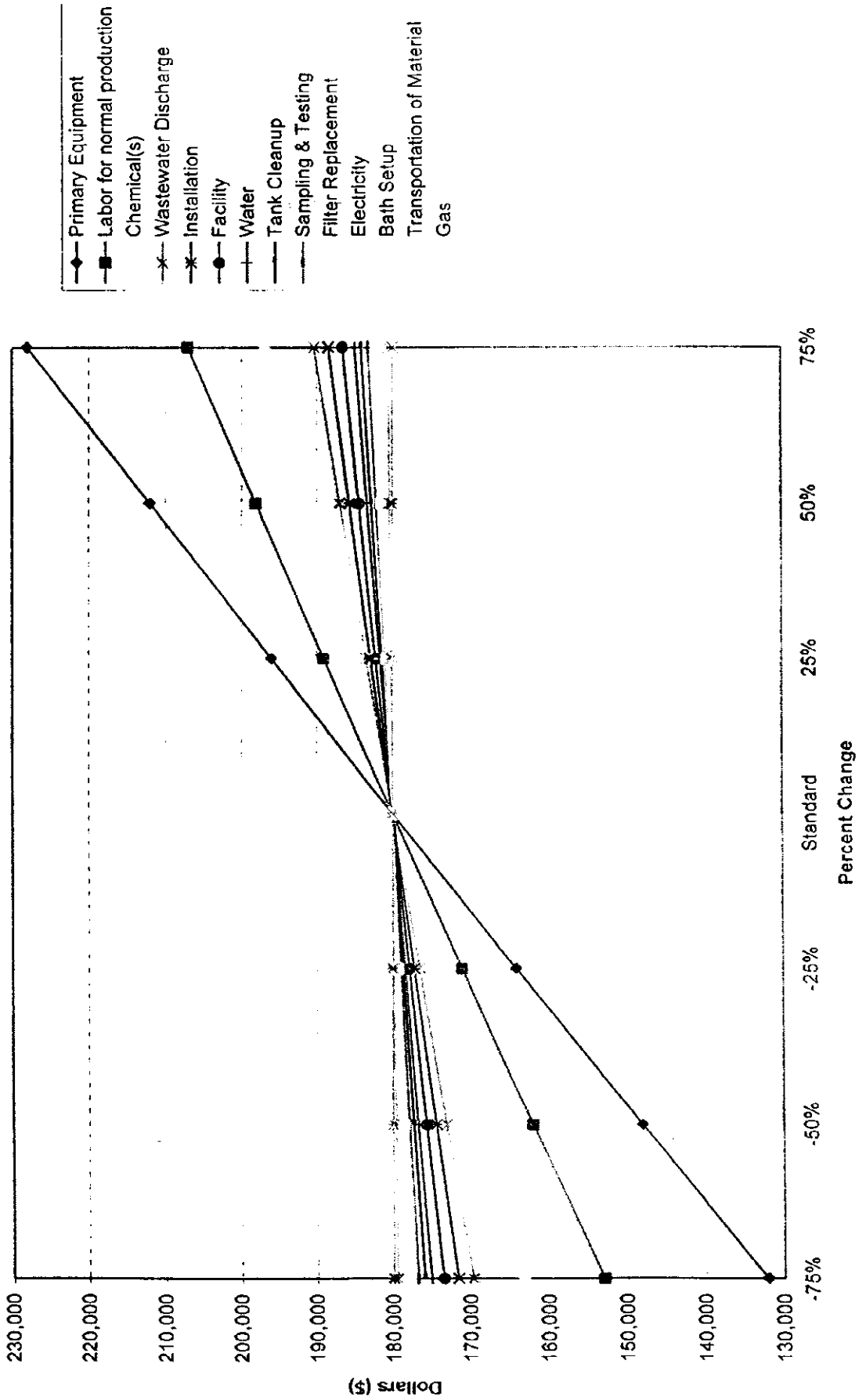
Process: Conductive Polymer¹

Bath	Total Bath Coat (Conveyorized)	Replacement Frequency (Conveyorized)	Annual Cost (Conveyorized)	Total Bath Cost (Non-Conveyorized)	Replacement Frequency (Non-Conveyorized)	Annual Cost (Non-Conveyorized)
Microetch		21		Not Avail.	NA	NA
Cleaner/Conditioner		13		Not Avail.	NA	NA
Catalyst		1		Not Avail.	NA	NA
Conductive Polymer		6		Not Avail.	NA	NA
Total						

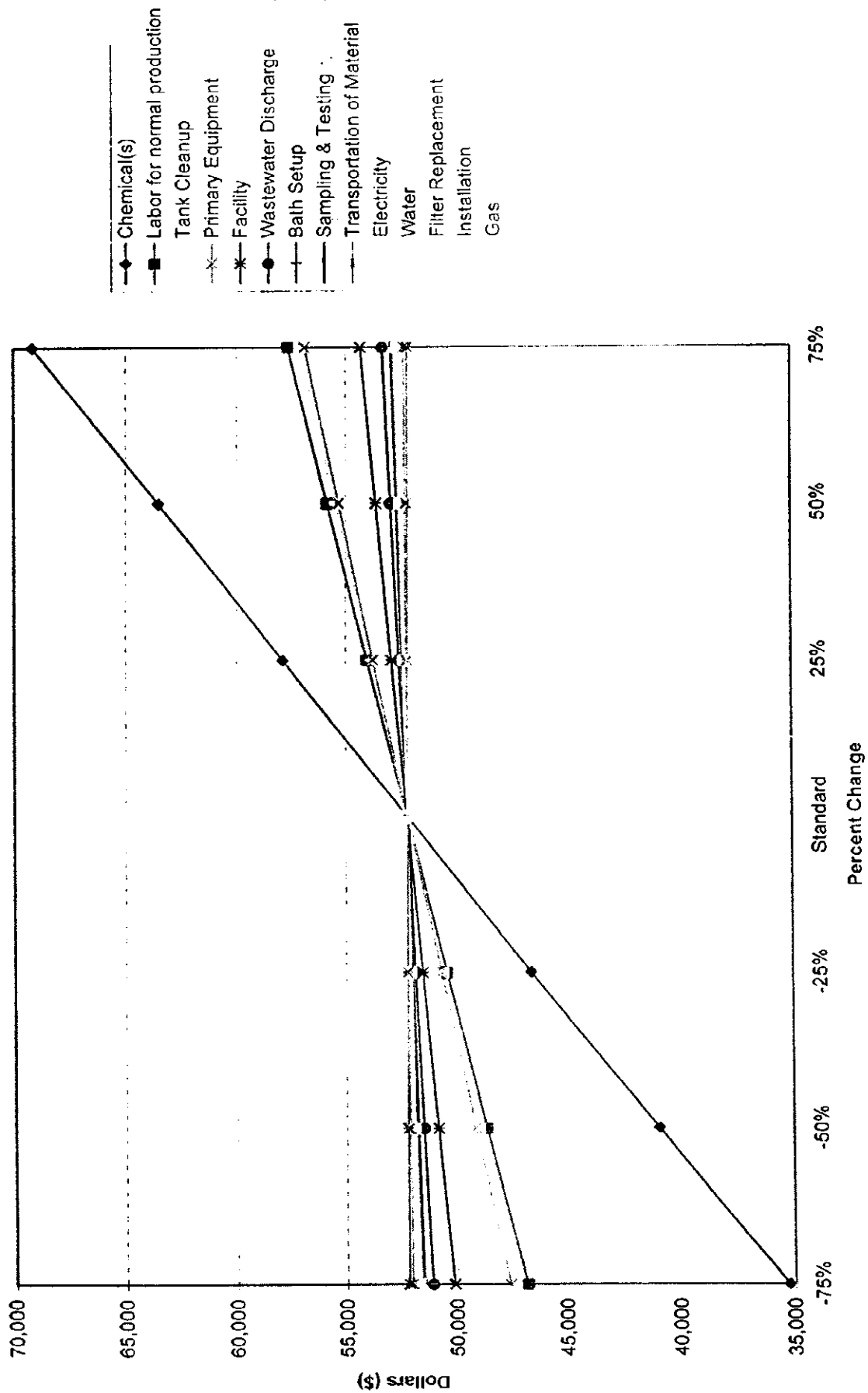
¹ Cost data were not available for all chemical products when this analysis was completed. These costs will be included in the final analysis.

G.6 Sensitivity Analyses

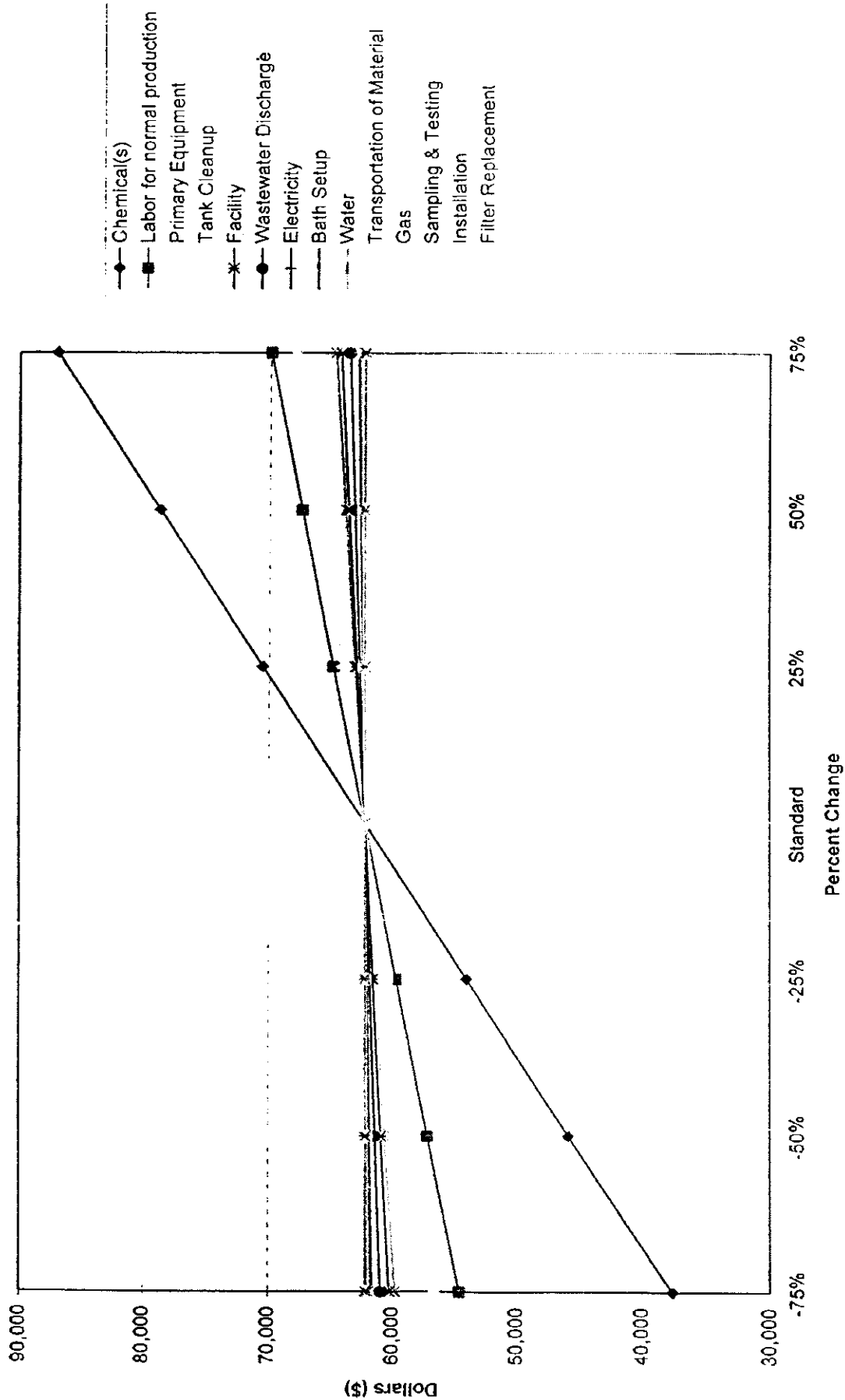
Sensitivity Analysis for the Non-ConveyORIZED Electroless Copper Process



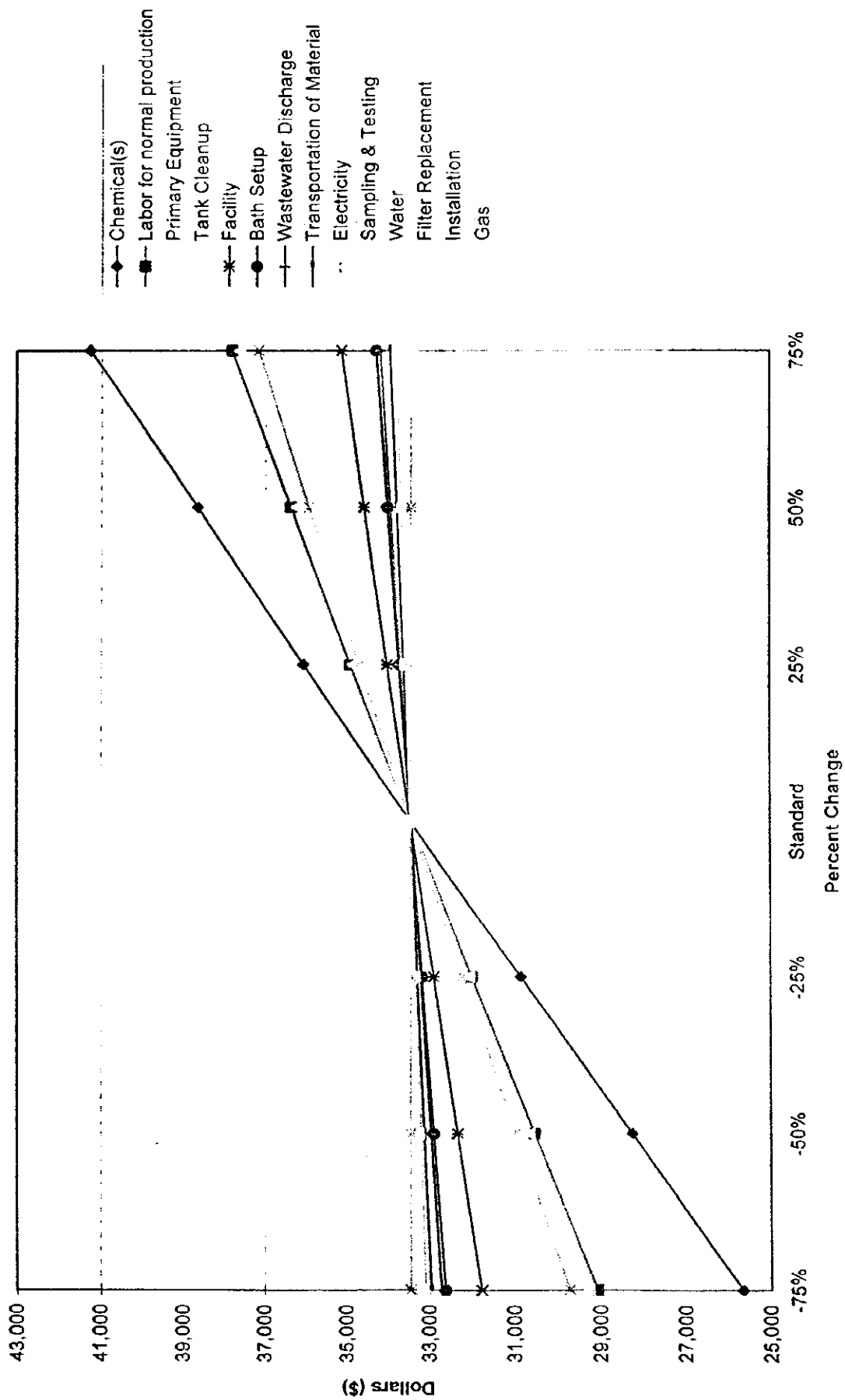
Sensitivity Analysis for the Conveyorized Electroless Copper Process



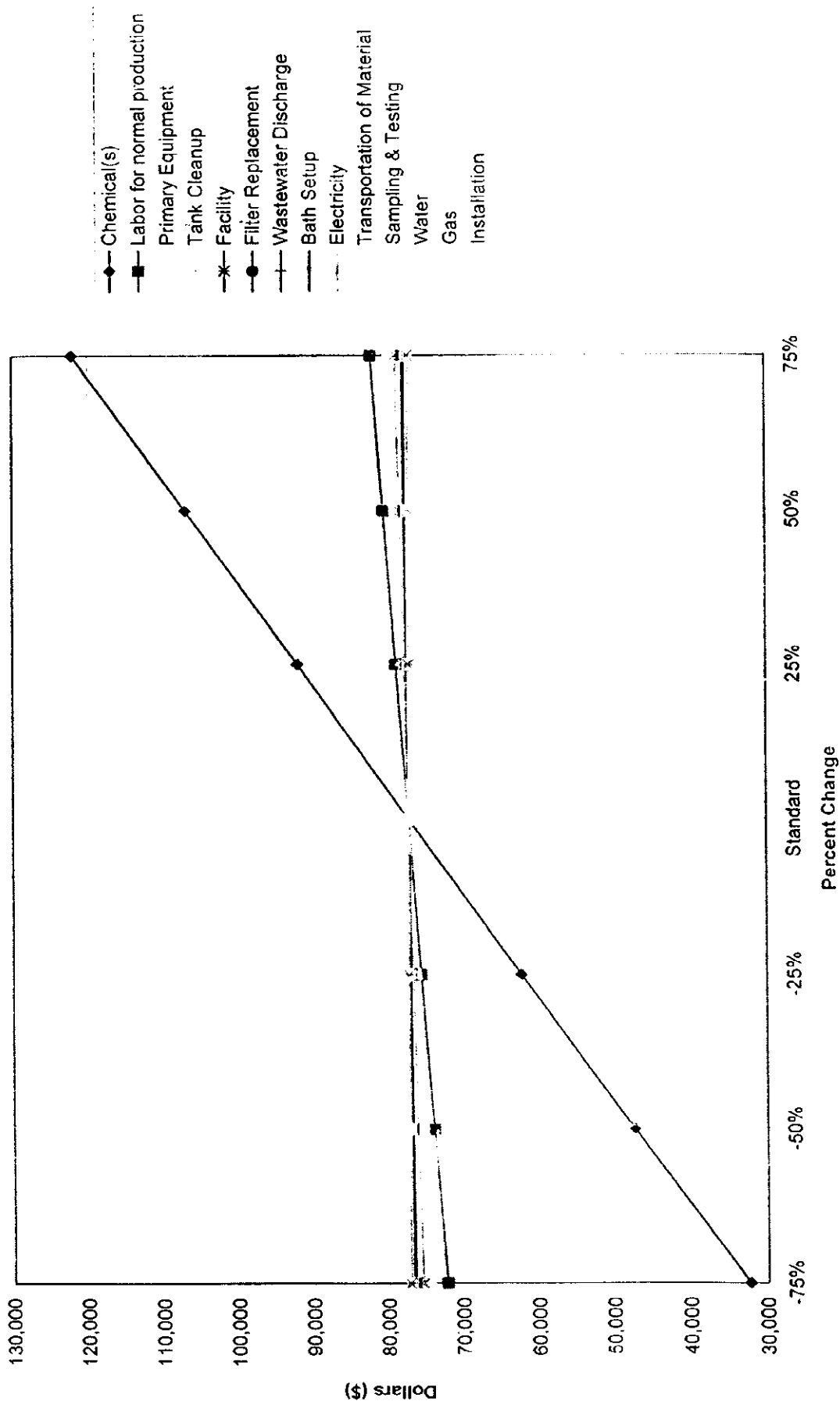
Sensitivity Analysis for the Conveyorized Carbon Process



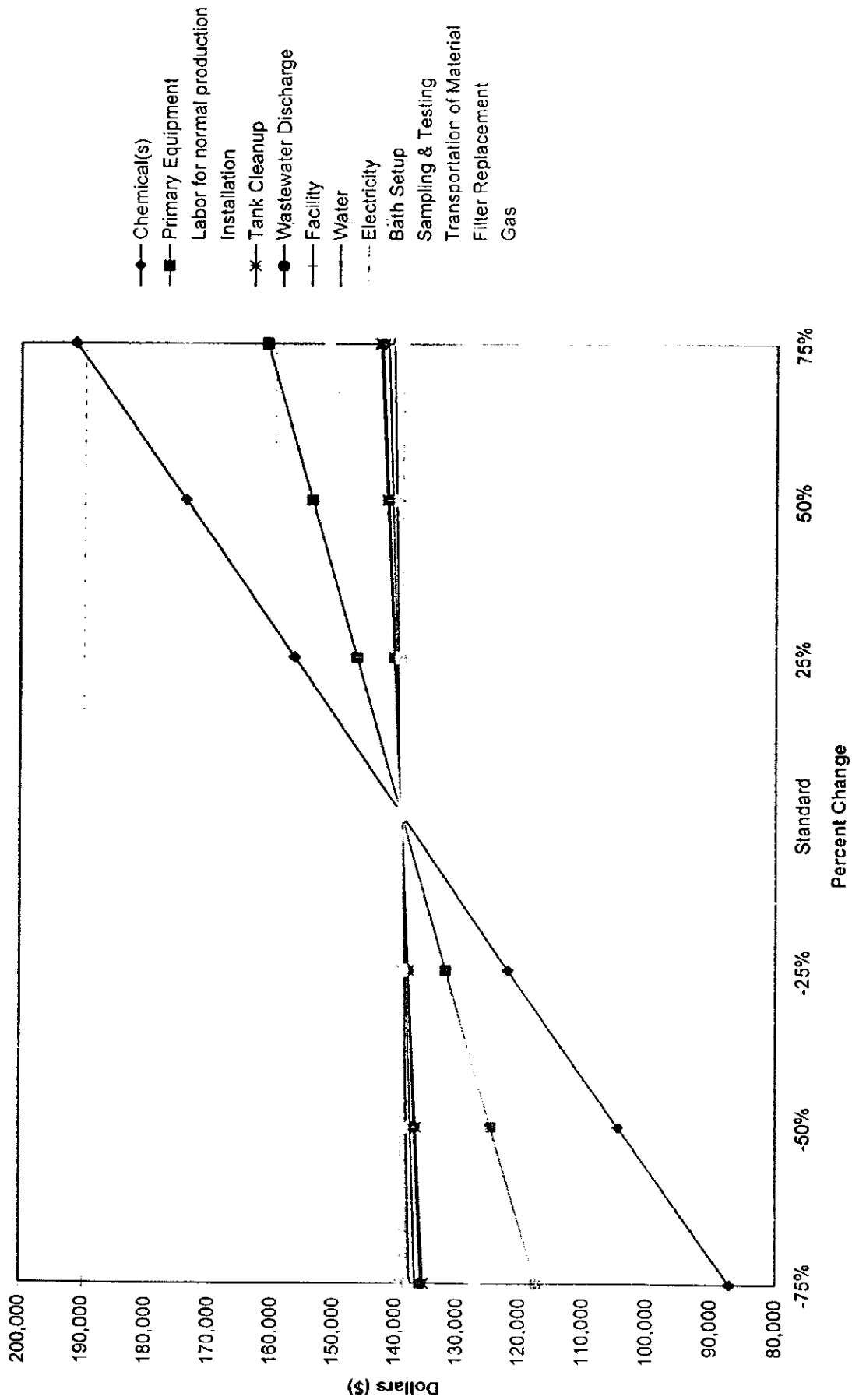
Sensitivity Analysis for the Conveyorized Conductive Polymer Process



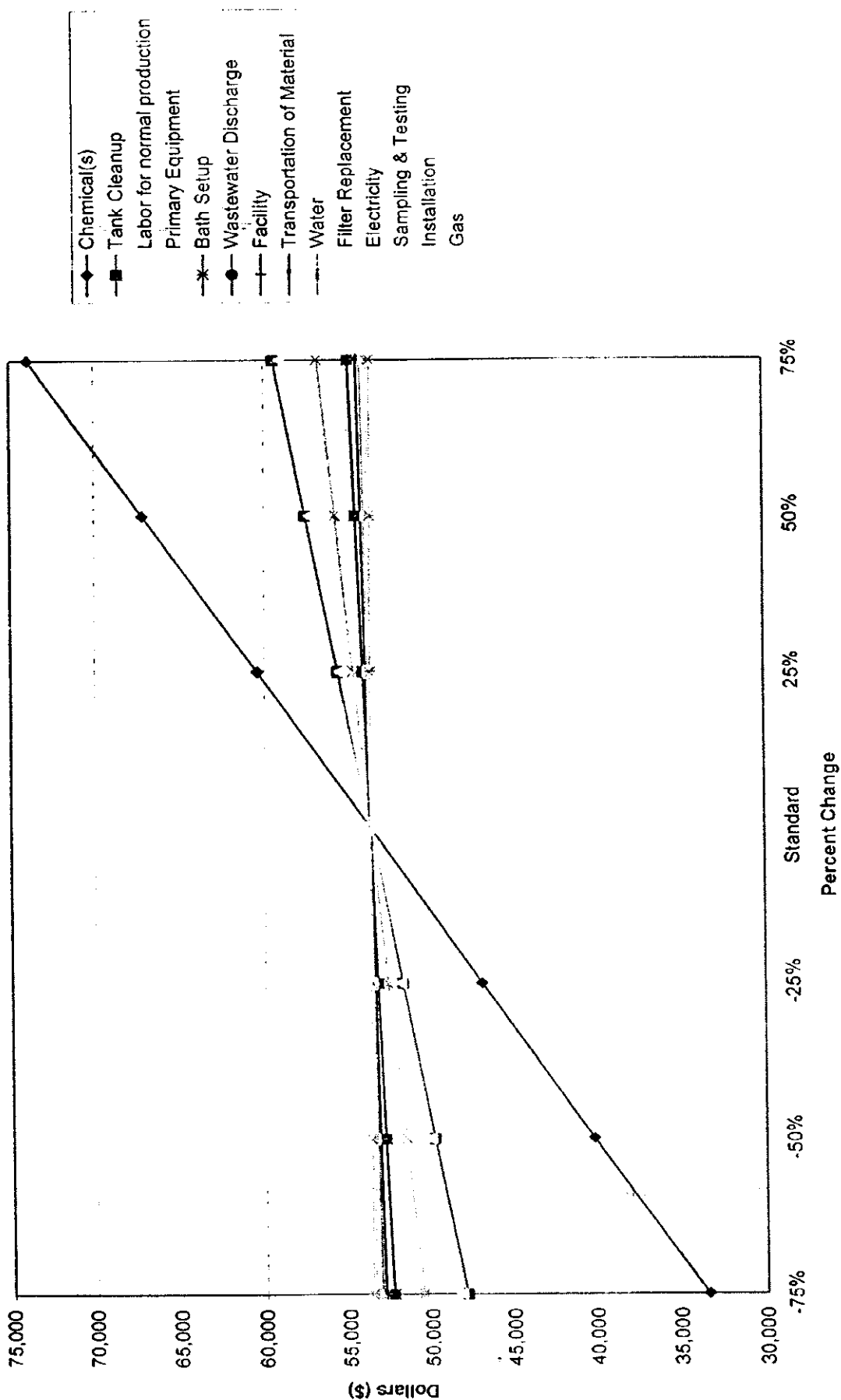
Sensitivity Analysis for the Conveyorized Graphite Process



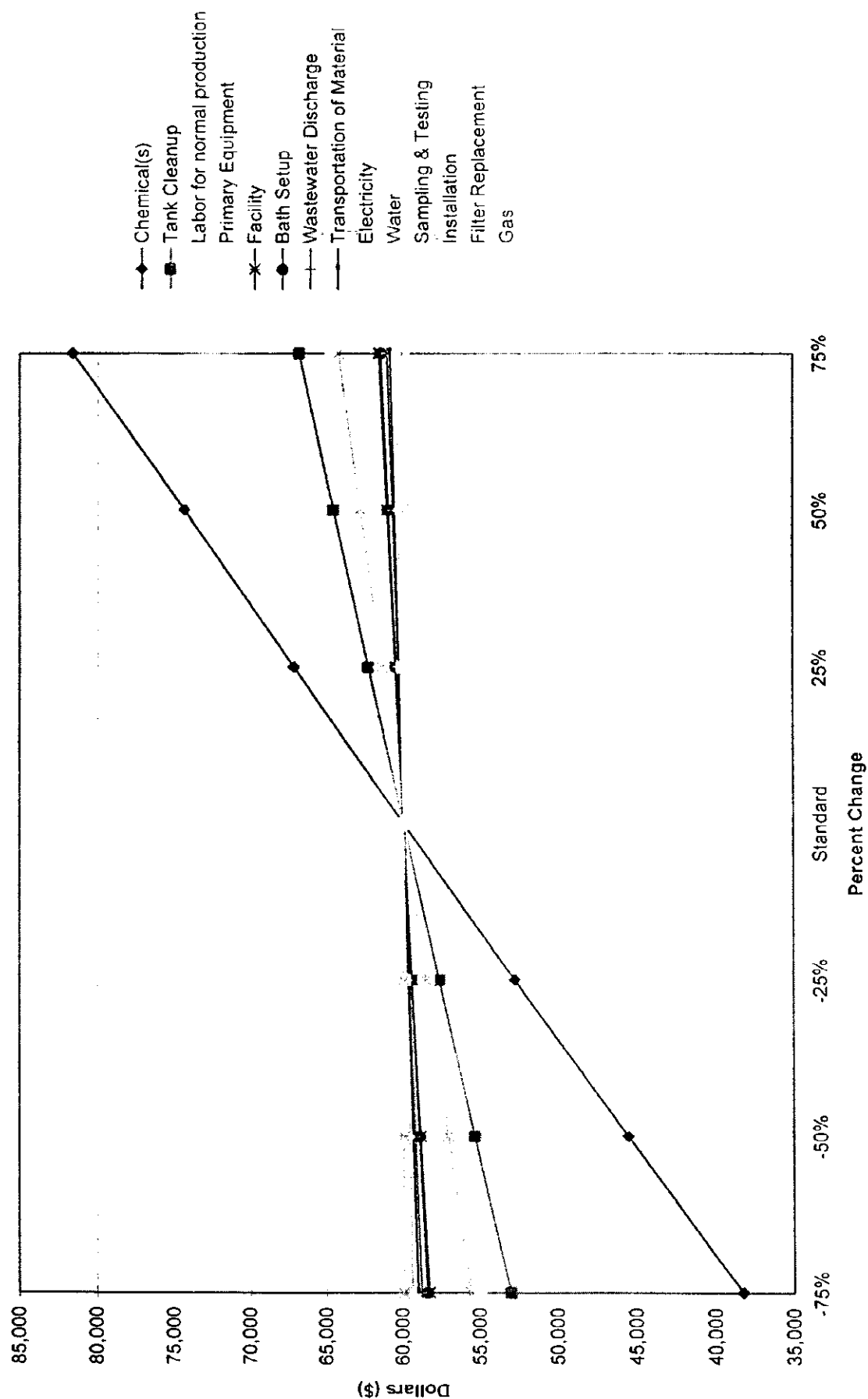
Sensitivity Analysis for the Non-ConveyORIZED Non-Formaldehyde Electroless Copper Process



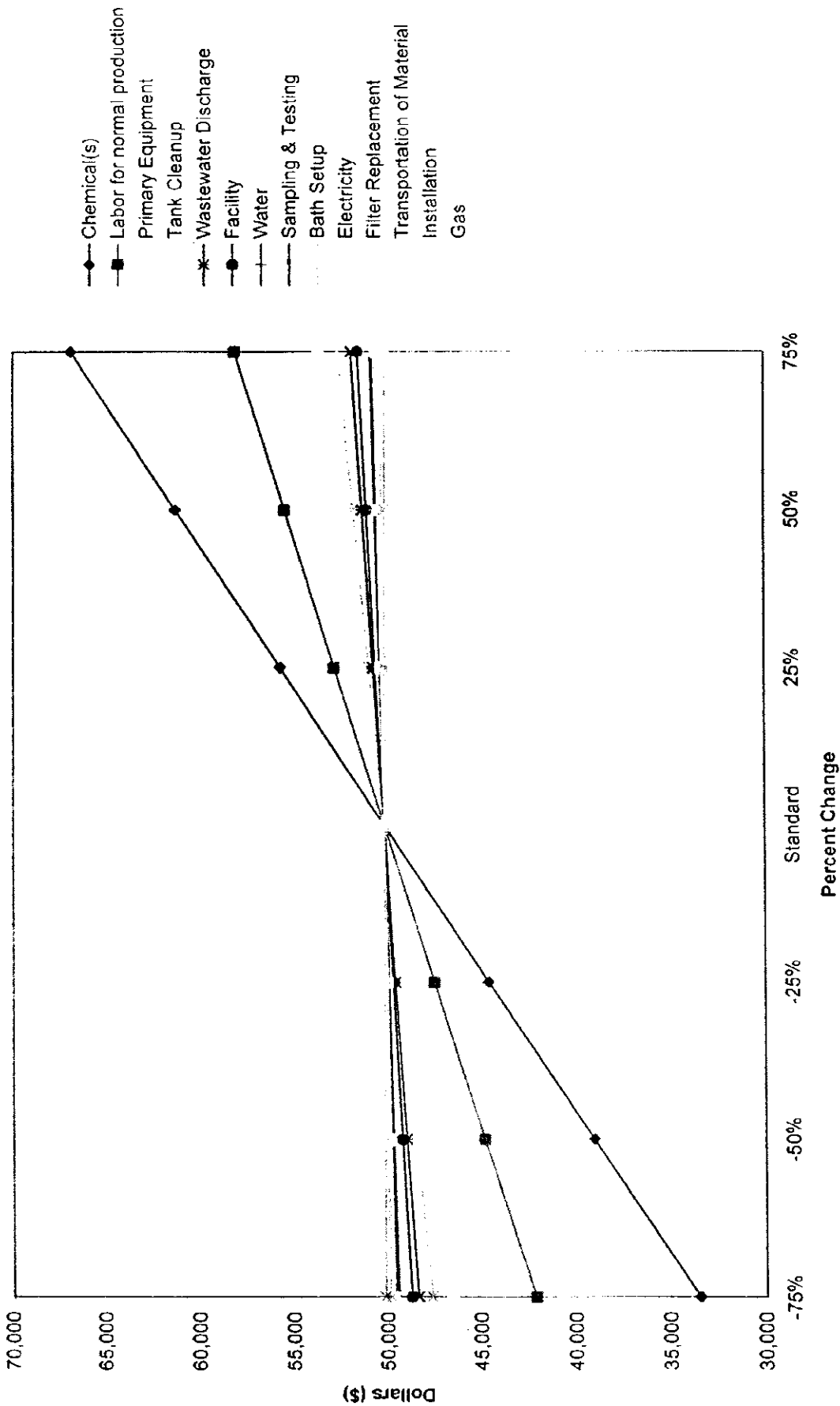
Sensitivity Analysis for the Non-ConveyORIZED Organic-Palladium Process



Sensitivity Analysis for the ConveyORIZED Organic-Palladium Process



Sensitivity Analysis for the Non-Conveyorized Tin-Palladium Process



Sensitivity Analysis for the ConveyORIZED Tin-Palladium Process

